NEW MATRICULATION ZOOLOGY

9

NEW MATRICULATION
ZOOLOGY 9

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To the teacher

New Matriculation Zoology is a series of five books developed for class 6-10 of the Tamil Nadu Matriculation system. It closely follows the new enriched Matriculation syllabus.

One of the main features of the new syllabus is that activity and observation are given a very important place in understanding science. Every effort has been made to unfold the scope and purpose of the syllabus. This series departs from the conventional and emphasises a practical, 'discovery' and 'learning by doing' approach.

The subject matter to be studied has been carefully arranged keeping in mind the age level and psychology of the child. No effort has been spared to support the text with clear, labelled illustrations. The language has been kept simple and direct to enable the students to read the text themselves.

Several activities and projects have been suggested, wherever possible, within the scope of the lesson. Most of these need simple improvising or inexpensive materials.

The exercises for each chapter are exhaustive and include questions based on comprehension and application of basic principles rather than on mere recall.

It has been the concern of the authors that children are encouraged to discover for themselves the pleasure of learning about the fascinating world of 'animals'.

The author

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New Matriculation Zoology 9

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MATRICULATION SYLLABUS FOR STANDARD IX – ZOOLOGY

S. No.	*Concept/theme*	*Expected learning outcome*	*Teaching / learning activities*
1.	**Organisation of animals**		
1.1	Skeletal system.		
1.2	Outline of structure and functions - exoskeleton of cockroach.	Sees relationship between exoskeleton and protection of internal organs.	Observes exoskeleton of crab, prawn, snail, etc., modification of exoskeleton-scales of fishes, garden lizard, feathers of birds, fur, hair of mammals, horns and hoofs of animals.
1.3	Endoskeleton of man - axial skeleton - skull vertebral column-thorax: appendicular skeleton - pectoral girdle and upper extremity: pelvic girdle and lower extremity.	Recalls types of bones and their uses in the human body.	Observes skeletal system of man, identifies each bone.
2.	**Physiology**		
2.1	Human physiology.		
2.2	Digestive system : structure and function of various parts of the digestive system.	Recalls the structure and function of alimentary canal.	Draws and labels the various parts of the human alimentary canal.
2.3	Study of ingestion digestion, assimilation and egestion.	Analyses the various physiological changes taking place in food at various parts of the alimentary canal. Recalls the structure and mode of functioning of the villi.	Prepares a tabular column showing the organs of digestion, secretory glands, secretions, composition, and their action on food.
2.4	Respiratory system.		
2.5	Structure of human respiratory system.	Recalls the various parts of the human respiratory system.	Lists the various components of the respiratory system.
2.6	Significance and need for respiratory system	Sees relationship between respiratory organs and their functions.	
2.7	Mechanism of respiration.	Analyses the process of inspiration and expiration.	Performs the bell jar experiment to understand inspiration and expiration.
2.8	Gaseous exchange in the alveoli and tissues.	Analyses the process of gaseous exchange in the alveoli and tissues.	
3.	**Cellular organisation.**		
3.1	Functional organisation of a generalised cell - a generalised cell does not exist as such. It is constructed by the biologists combining the common features of plant and animal cells - nucleus and the cytoplasm.	Recalls the generalised cell. Understands cells are not all the same.	Points out the different cytoplasmic and nuclear inclusions. Microscopic examination.

S. No.	Concept/theme	Expected learning outcome	Teaching / learning activities
3.2	Cell theory - one of the foundation stones of modern biology.	Recalls cell theory.	Microscopic examination of plant and animal cells.
3.3	Light microscopic structure of plant and animal cells (eucaryotic) - the organelles and how they are present in plants and animal cells-the relationship between organelles.	Recognises organelles in pictures.	
3.4	Structure of cell as revealed under electron microscope. - the ultrastructure and the organelles in individual cells - specific functions - how they are integrated in an orderly manner.	Recognises the parts of ultrastructure cell in a picture.	Pictures of ultrastructure of cell organelles in plants.
3.5	Difference between plant and animal cell in detail - (cell wall; vacuole, centrosomes, plastids).	Discriminates between plant and animal cells.	
3.6	Chromosome number and importance, chromosome number in plants, man and fruit fly. Autosome and sex chromosomes (elementary knowledge).	Classifies chromosomes as autosomes and sex chromosomes; realises the importance of the role of chromosomes in heredity.	Prepares a chart to show chromosome number of common plants, animals and man.
3.7	Cell division (detailed study).	Analyses how new cells arise from existing cells by division.	Observes models on division.
3.8	Mitosis and its significance.	Recalls the process of mitosis and its significance.	Identifies each phase of mitosis in prepared slides.
4.	**Nutrition and hygiene**		
4.1	Role of enzymes in digestion.	Infers that enzymes act as catalysts.	Prepares a list of digestive enzymes in man.
4.2	Pathogenic forms - Entamoeba histolytica, Entamoeba gingivalis-their role in human health. Ascaris — mode of infection. Aflatoxins-food poison.	Recalls pathogenic forms and their roles.	Observes slides of specimens Entamoeba (sp) liver fluke, tapeworms, pinworms, threadworms, Ascaris, etc.,
	(a) Entamoeba		
	(b) Ascaris - production of aflatoxins.		
4.3	Contamination of food.	Recalls the ways of food contamination and its prevention. Realises the seriousness of food contamination.	Taking the students to health centres to see patients suffering from taking in contaminated food.

S. No.	Concept/theme	Expected learning outcome	Teaching / learning activities
5.	**Reproduction, inheritance and evolution.**		
5.1	Physical basis of heredity (DNA) - chromosomes - factors (genesis) DNA and RNA - their significant role.	Analyses the role of DNA and RNA.	Display of Watson and Crick model of DNA molecule.
5.2	Chemical structure of nucleic acids - (elementary level) - double helix structure (DNA) and single stranded structure (RNA)- difference in their bio-chemical organisation.	Discriminates between DNA & RNA in their structure and function.	Showing film on DNA and RNA.
5.3	Evolution.		
5.4	Evolution as a process-origin of life on earth (elementary knowledge only) - phenomenon of descent with change; formation of new types; modification of already existing forms. Recognises the formation of new species due to genetic variation, perpetuation in the next generation through inheritance and isolation from the original stock brief history- special creation-catastrophism, spontaneous creation, cosmozoic theory brief outline.	Recall various theories of evolution.	Tree of evolution-group work.
5.5	Evidence of evolution-Pasteur's experiment- Miller's experiment - sees the various evidences; Pasteur's concept - life arising from pre-existing life; Pasteur's experiment- continuity of life; Uray-Miller's experiment- chemo-synthetic origin.	Recalls various evidences cited for evolution.	Collects picture of various scientists Darwin, Pasteur, Miller, and notes their contribution.
5.6	Evidences from comparative anatomy. - sees the progressive complexity - brain and heart vertebrates - homologous, analogous, vestigial organs, atavism.		Examines these organs and comparative study.
5.7	Evidences from palaeontology.		Prepares posters.
5.8	Evidences from embroyology (embryo of fish to man) - formation of fossil, distribution of fossils, missing links, fossil history. Similar early development, similarity in vertebrate		Observes various embryos (fish to man) preserved specimens.

S. No.	Concept/theme	Expected learning outcome	Teaching / learning activities
	embryos. Biogenetic law (von Baer), temporary embryonic organs, recapitulation theory (Haeckel)		
5.9	Darwin's theory of organic evolution. - Charles Darwin's biography, the main features of Darwinism-competition or struggle for existence, (intra-specific, inter-specific) environmental variation. Natural selection or survival of useful variation, formation of new species.	Analyses Darwin's theory of evolution into its components.	
5.10	Heredity and variation.	Recalls the major concepts of heredity and variation.	
5.11	Causes of variation - types of variation - heredity or germinal variation (recombination of gene, supernumerary or extra chromosomes, gene mutation).	Recalls the cause of variation, genotype and phenotype; environmental or acquired variations (environmental factors-sun tanning, heterophylly in aquatic plants); conscious efforts; use and misuse of organs.	Observes Tanuculus aquatilis. Training of pets, boring of pinna. Supernumerary chromosomes Datura; algae, cladophora, syndactyly, polydactyly, albinism, classroom/school.
6.	**Organisms and environment.**	Sees relationship between organisms and their modes of adaptations to their environment.	
6.1	Adaptation - the outcome of prodigality of production, the stress and strain of the struggle for existence, diversification of plants and animals to suit different modes of life and habits.		
6.2	Adaptation-definition. How animals tend to invade different ecological niches and undergo diversification-each region, how it is varied in its topography, soil, climate and vegetation -diversification of fauna and flora.	Analyses different types of organisms with reference to their modes of adaptation.	Examination of plant like opuntia lotus for adaptation to the environment.
6.3	Types of adaptations in animals on the basis on nutritional habits and habitat (elementary knowledge only) - ocean habitat, terrestrial habitat (tundra, deciduous, tropical, desert, etc.,) freshwater habitat, epiphytes, parasites, symbionts, and special adaptations. Fossorial, aquatic, arboreal, volant, active and passive flight. Social life of bees.	Analyses types of adaptation of organisms on the basis of nutritional habits and habitats.	Film show on adaptation and adaptive radiation.

S. No.	Concept/theme	Expected learning outcome	Teaching / learning activities
6.4	Colouration and mimicry - protective mechanism and better survival of the species-kind with examples; colouration. - concealing resemblances-flash warning and signalling-protective aggressive and alluring colouration with suitable examples.	Analyses protective colouration and mimicry seen in organisms.	Observation of leaf insect Phyllum in habitat (preserved specimens) Observation of chameleon in the laboratory in different backgrounds. Visit to zoological parks.

PRACTICALS

1.Identification of exoskeleton (Crabs, prawns and snails).

2.Identification of (a) typical Vertebra (b) skull (c) bones of fore arm and legs.

3.Identification of liverfluke, tapeworm, pin worm, ascaris, leaf insect and Chameleon (preserved specimens).

4.Bell iar and balloon experiment to demonstrate the mechanism of breathing.

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1. Organisation of animals

Skeletal system - outline of structure and functions - exoskeleton of cockroach-endoskeleton of man - axial skeleton - skull-vertebral column - thorax - appendicular skeleton - pectoral girdle and upper extremity - pelvic girdle and lower extremity.

1.1 The skeletal system

Mammals have to support themselves, maintain their body shape, and move about on dry land without the help of the buoyancy that water gives to aquatic animals. Mammals are able to adapt themselves to terrestrial environment mainly because of three kinds of tissues. They are:

1. *bone*, which forms the skeleton, an internal framework of articulated levers.
2. *muscle*, which does work by contraction.
3. *tendons and ligaments*, which attach muscles to bones and bones to bones respectively.

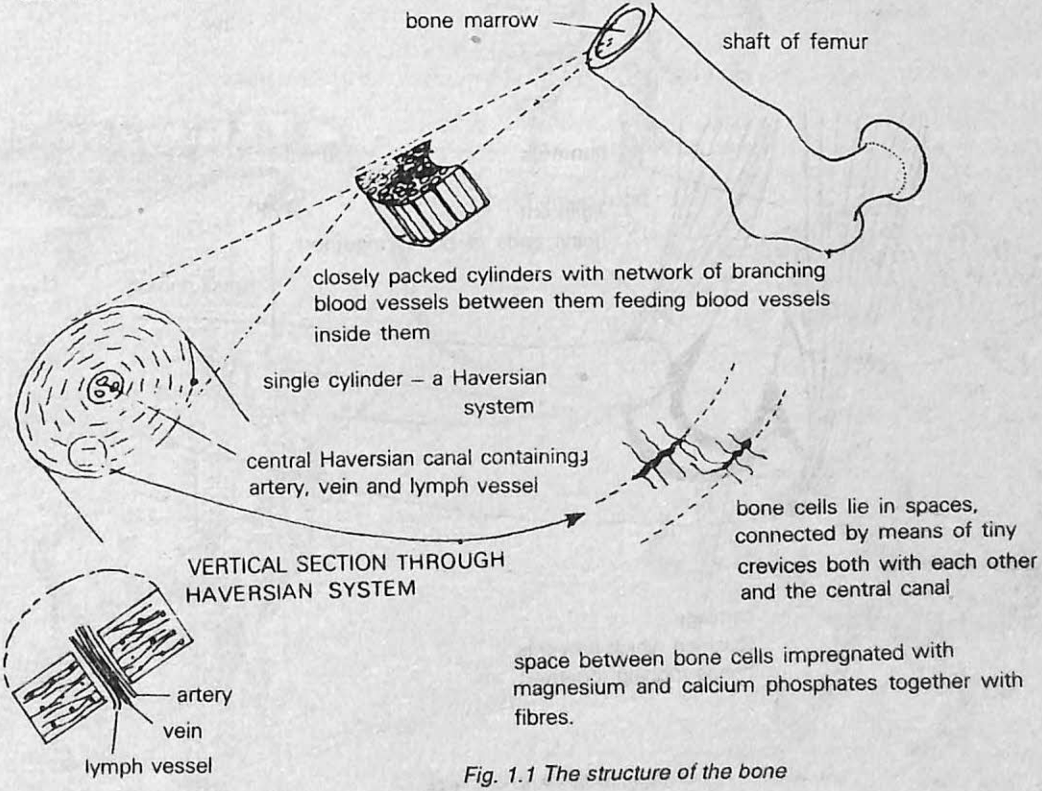
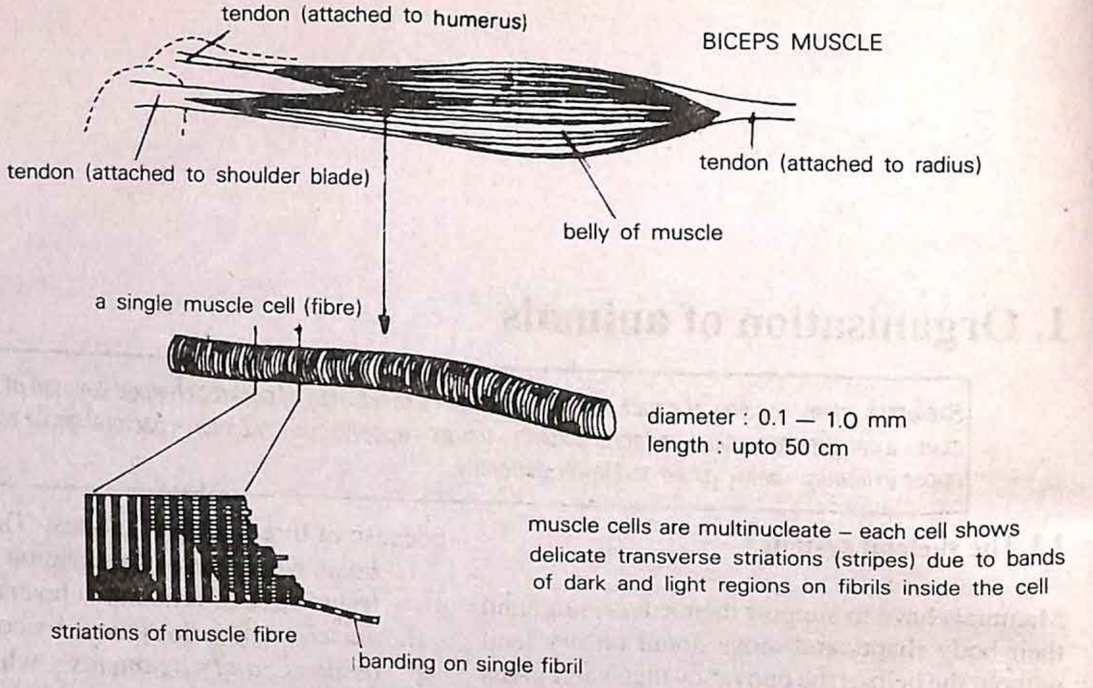

bone marrow
shaft of femur
closely packed cylinders with network of branching blood vessels between them feeding blood vessels inside them
single cylinder – a Haversian system
central Haversian canal containing artery, vein and lymph vessel
bone cells lie in spaces, connected by means of tiny crevices both with each other and the central canal
VERTICAL SECTION THROUGH HAVERSIAN SYSTEM
artery
vein
lymph vessel
space between bone cells impregnated with magnesium and calcium phosphates together with fibres.

Fig. 1.1 The structure of the bone


tendon (attached to humerus)
BICEPS MUSCLE
tendon (attached to shoulder blade)
tendon (attached to radius)
belly of muscle
a single muscle cell (fibre)
diameter : 0.1 — 1.0 mm
length : upto 50 cm
striations of muscle fibre
banding on single fibril

muscle cells are multinucleate – each cell shows delicate transverse striations (stripes) due to bands of dark and light regions on fibrils inside the cell

Fig. 1.2 The structure of the muscle

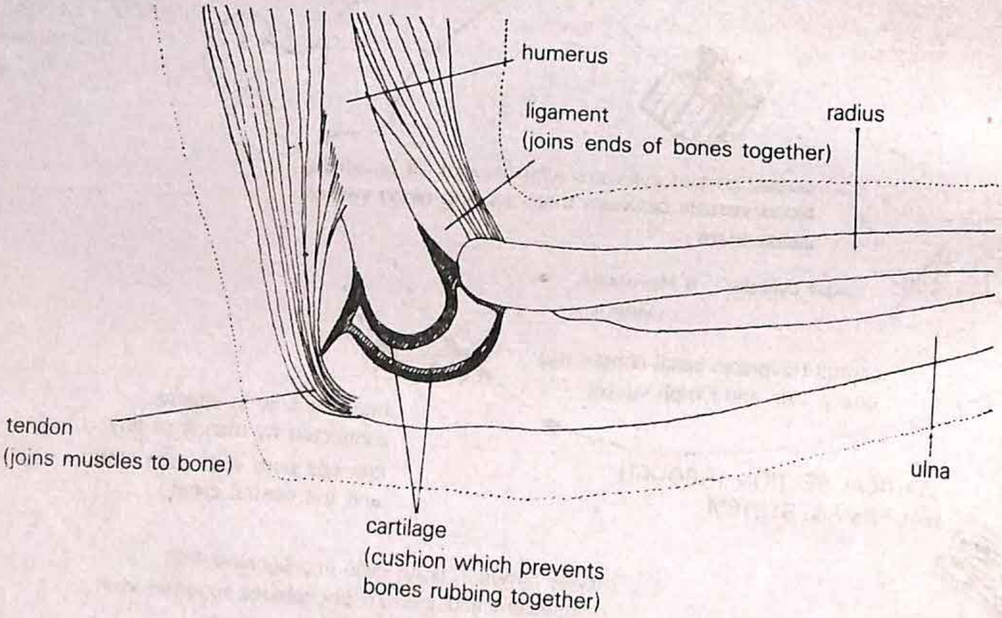


Fig. 1.3 Ligaments and cartilage

Bones are mainly *resistant to compression,* although they have a high resistance to bending and stretching forces also. Ligaments and tendons have great *tensile strength,* like ropes. Muscles do work by contracting, although they too act like ropes. In an adult mammal the skeleton is composed mainly of bone, but *cartilage,* a flexible, elastic skeletal-tissue with a smooth, glossy appearance, is present in the joints where two bones move against each other. In the embryo, however, the only skeletal tissue present is cartilage, but it is largely replaced by bone during growth. Both these tissues contain a high proportion of non-living material or ground substance which has been secreted by the living cells of the tissue.

In the vertebrates, since the bones and cartilages lie inside the body, the skeleton is said to be an *endoskeleton.* The formation of the endoskeleton is one of the characteristic features of vertebrates.

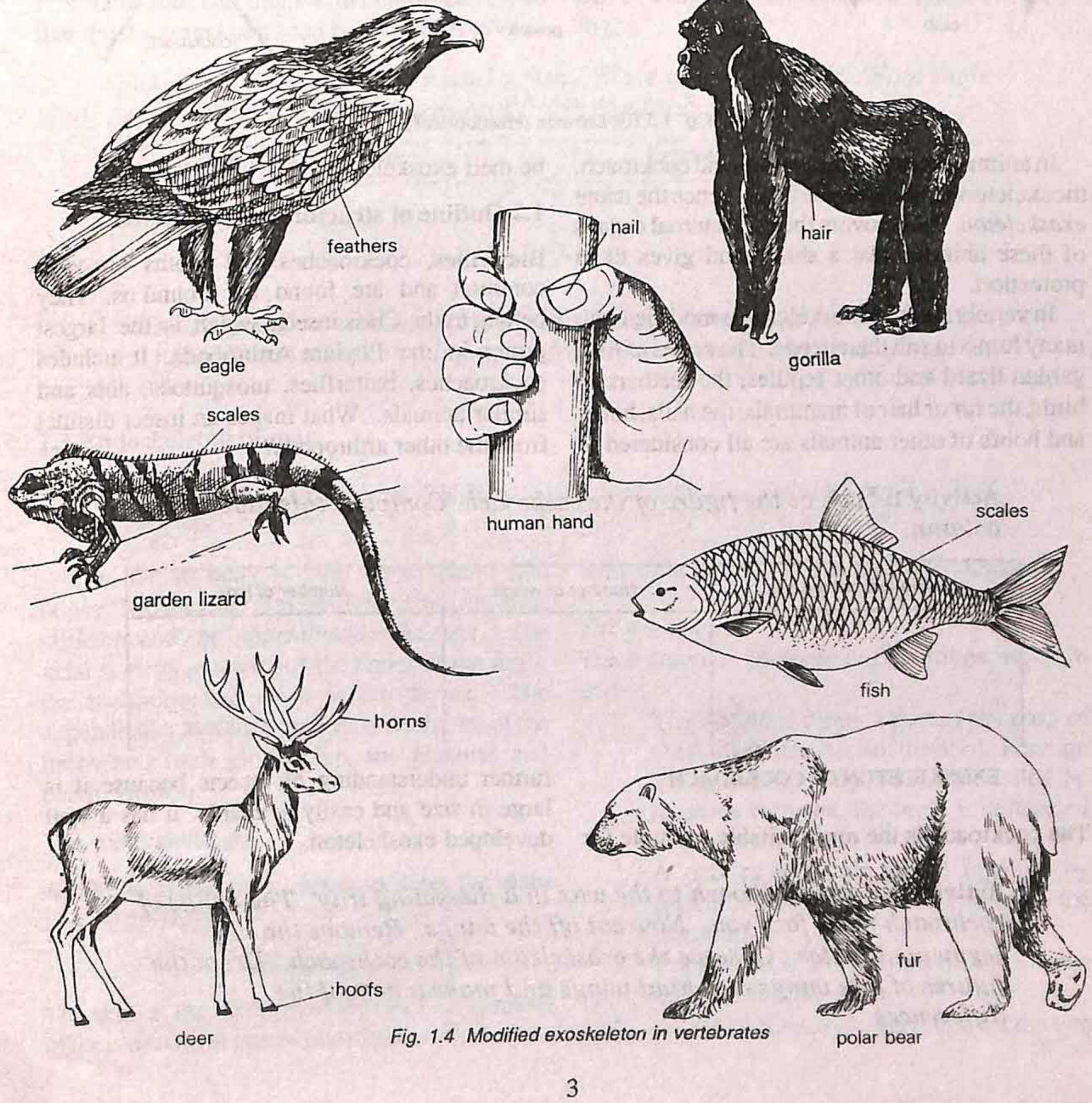


Fig. 1.4 Modified exoskeleton in vertebrates

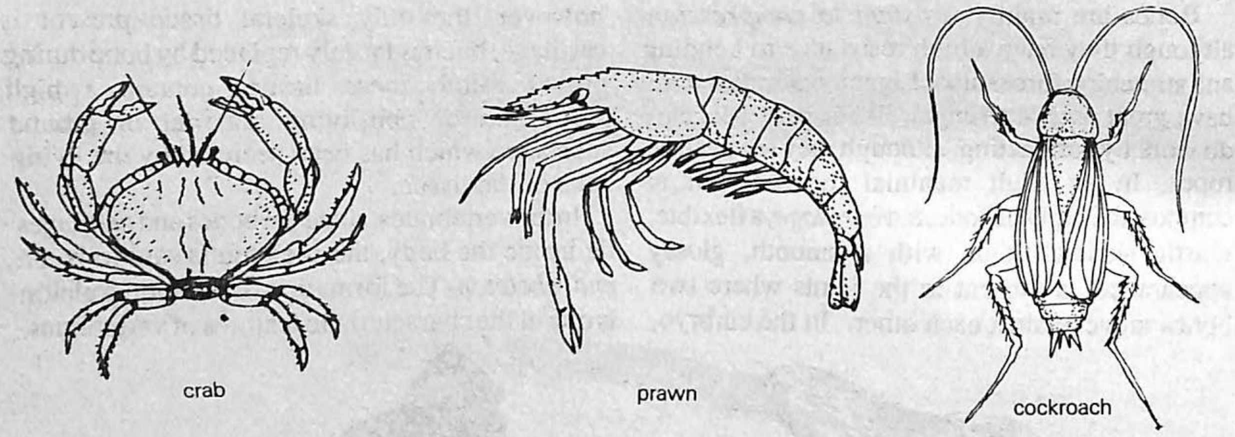


Fig. 1.5 Exoskeleton (invertebrates)

In animals like the crab, prawn and cockroach, the skeleton lies outside the body, hence the name *exoskeleton.* This covers the soft internal organs of these animals like a shield and gives them protection.

In vertebrates the exoskeleton is modified into many forms to suit their needs. The scales of fish, garden lizard and other reptiles, the feathers of birds, the fur or hair of mammals, the nails, horns and hoofs of other animals are all considered to be their exoskeletons.

1.2 Outline of structure and functions

Butterflies, cockroaches and moths are very common and are found all around us. They belong to the Class insecta which is the largest group in the Phylum Arthropoda. It includes cockroaches, butterflies, mosquitoes, ants and similar animals. What makes an insect distinct from the other arthropods?

Activity 1: *Look at the figure of the cockroach. Complete this tabular column.*

The distinct regions	*Number of wings*	*Number of legs*

EXOSKELETON OF COCKROACH

The cockroach is the most suitable example for further understanding of insects because it is large in size and easily available. It has a well developed exoskeleton.

Activity 2: *Pin a cockroach to the wax in a dissecting tray. The wings of cockroach must face you. Now cut off the wings. Remove the segmented plates. Observe the exoskeleton of the cockroach. Draw the figures of fore wings and hind wings and make a note of the differences.*

The body of the cockroach is a covered by a reddish brown *cuticle* which is impervious to water and is thick and tough enough to protect the internal organs of the body. This skeleton provides stiffening for the limbs and gives definite shape to the body. It facilitates movement in much the same way as the bones of mammals do, but in this case the skeleton is external to the muscles which are attached to it. The exoskeleton covers the whole body and is therefore provided with joints. It remains thin and flexible in certain places, so that the thickened parts can be moved relative to one another. The body is flattened from above and below, which helps the insect to remain hidden in crevices.

The exoskeleton of the cockroach can be divided into a. exoskeleton of the head b. exoskeleton of the thorax, and c. exoskeleton of the abdomen. The thorax bears two pairs of wings. The first pair of wings are not useful for flight but serve to cover the hind wings and the abdomen. These are known as *elytra*. The second pair of wings are membranous. These are used in flight.

Activity 3: *Collect a* prawn *and a fish. Place them in a tray. Note their similarities and differences and fill in the table given below:*

External features of prawn	External features of fish

Activity 4: *Examine the feathers of the down and quill variety. If possible examine the wing of a bird to see the arrangement of the feathers.*

1.3 Endoskeleton of man

Activity 5: *Observe the skeletal system of man and identify each bone.*

The human body is built up of about 206 bones. The skeleton may be divided into the *axial skeleton* and the *appendicular skeleton*. The axial skeleton consists of the bones of the head, the backbone and those of the thorax. The appendicular skeleton consists of the bones of the limbs and limb girdles (i.e. the pectoral and pelvic girdles).

The axial skeleton

As the name indicates, this constitutes the main axis of the body.

THE SKULL

The skull is the skeleton of the head. It consists of the *cranium* (brainbox) and the *face*, the former with eight bones and the latter with fourteen.

The cranium

The cranium is composed of the following eight bones:

1. The *occipital* forms a part of the base of the skull and the back of the head. Through a large oval opening in this bone called the *foramen magnum*, the brain is connected to the spinal cord.
2. A pair of *parietals* joined together by parietal sutures, forms the centre of the cranium.
3. The *frontal*, in front, forms the broad bone on the forehead.
4. A pair of *temporals* are found on the two

sides of the frontal.

5. A large wedge-shaped bone called the *sphenoid* lies in front of the temporals and the occipital forming the base or the floor of the cranium.
6. The *ethmoid* lies in front of the sphenoid.

The facial bones

The following fourteen bones are found in the front part of the skull forming the facial region.

1. A pair of *maxillary bones*, the *maxillae*, forming the upper jaw.
2. A pair of bones of the cheek called the *malar bones* or the *zygomatic processes* given off from each maxilla to meet a process of the temporal bone of that side.
3. *The palatines*, a pair of bones forming the roof of the mouth.
4. *The lachrymals*, a pair of small bones, one on each orbit of the eye, formed for the *naso-lachrymal duct* which conducts tears from the eye to the nasal cavity

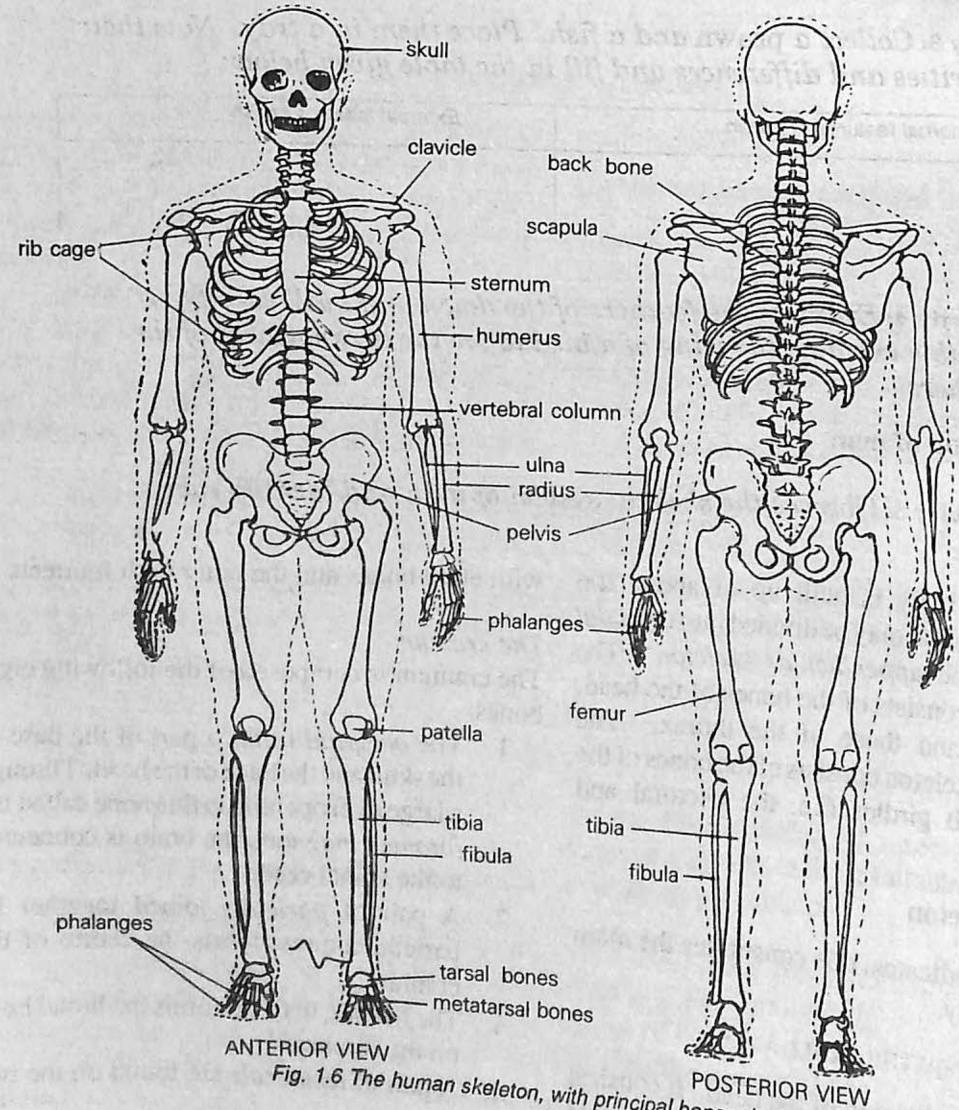
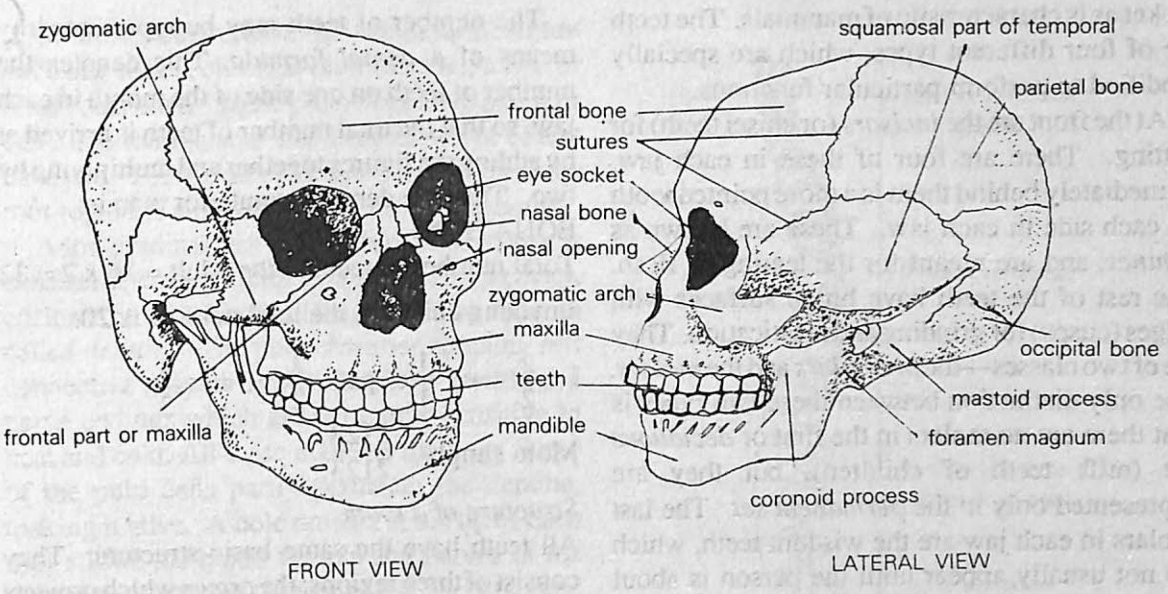


Fig. 1.6 The human skeleton, with principal bones designated



FRONT VIEW

LATERAL VIEW

Fig. 1.7 Skull of man

5. *The nasals,* a pair of small bones arranged side by side, forming the bridge of the nose.
6. *The vomer,* a thin flat bone, below and behind the middle septum which divides the nasal cavity into two.
7. *The inferior turbinals,* a pair of bones projecting from the maxillae.
8. *The mandible,* the largest and the strongest bone of the face — movable and joined with the upper jaw.

Besides the above mentioned bones the ear bones are situated on the two sides of the cranium, where the two jaw bones meet. In the ear are the *periotic bone* and the three tiny bones of the middle ear.

Both the upper and the lower jaws are provided with a set of teeth, each of them embedded in a

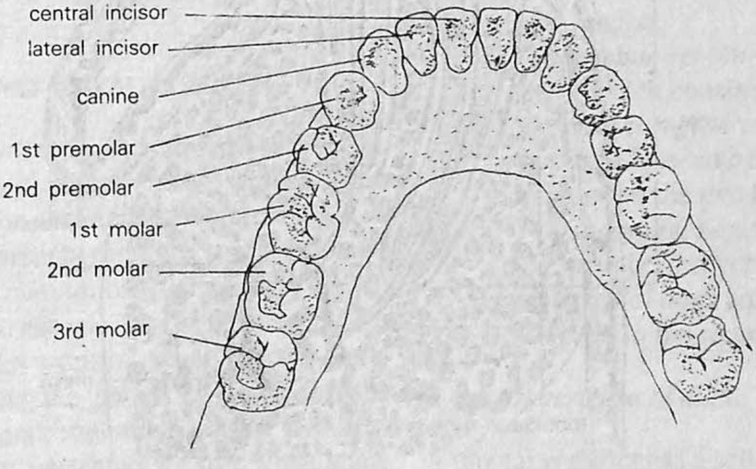


Fig. 1.8 Dentition of man : lower permanent teeth

socket as is characteristic of mammals. The teeth are of four different types, which are specially modified to perform particular functions.

At the front are the *incisors* (or chisel teeth) for cutting. There are four of these in each jaw. Immediately behind them is a more pointed tooth on each side in each jaw. These are known as *canines*, and are meant for the tearing of flesh. The rest of the teeth have broad surfaces with ridges (cusps) for grinding and mastication. They are of two classes—the *premolars* and the *molars*. The only distinction between these two types is that there are no molars in the first or *deciduous set* (milk teeth of children), but they are represented only in the *permanent set*. The last molars in each jaw are the wisdom teeth, which do not usually appear until the person is about twenty years old. In the adult there are two premolars and three molars on each side, in each jaw.

The number of teeth may be represented by means of a *dental formula*. This denotes the number of teeth on one side of the mouth in each jaw, so that the total number of teeth is arrived at by adding the figures together and multiplying by two. Thus the dental formula for man is:
EQUATION

Total number of teeth in the adult = 16 x 2 = 32

In young children, the total number is 20.

$$i\ \frac{2}{2} : c\ \frac{1}{1} : pm\ \frac{2}{2} : m\ \frac{3}{3}$$

More simply, $\frac{2123}{2123}$

Structure of a tooth

All teeth have the same basic structure. They consist of three regions: the *crown* which projects above the gums, the *root* which lies embedded in the jaw bone, and the *neck* which is the junction

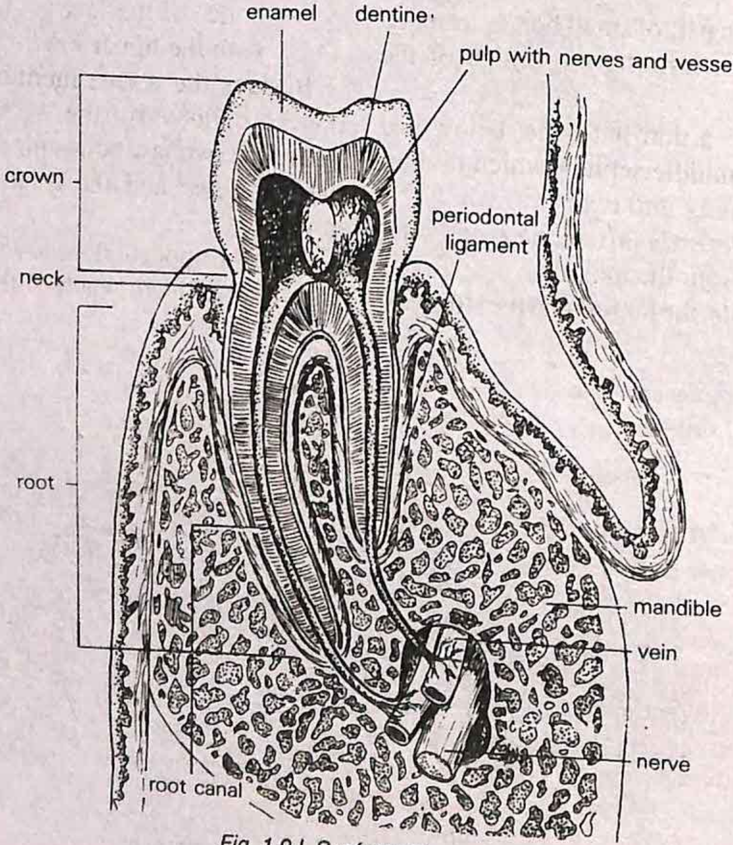


Fig. 1.9 L.S. of a tooth

of the crown and the root. All incisors and canines have one root each while all molars have two or three roots each. Some premolars have one root each like the incisors and canines while others have two. The socket in the jaw bone in which the root region is embedded is called the *alveolus*.

A longitudinal section of a tooth shows that it consists of a central *pulp chamber*, or *pulp cavity*, enclosed by a thick layer of hard bone-like material called *dentine*. The pulp chamber contains soft connective tissue in which lie blood vessels and nerve endings which are extremely sensitive to heat and cold. All these make up the *pulp*. Some of the pulp cells partly permeate the dentine, making it alive. A hole present at the tip of each root allows the blood vessels and nerves of the pulp to be connected to those of the jaw bones and gums.

The dentine of the crown and neck is capped with a thin layer of hard but brittle non-living material. This material, which is white in colour, contains calcium salts and is called *enamel*. It protects the dentine and the pulp within.

In the root region, the dentine is not capped by enamel but by a thin layer of *cement*, a bone-like material. The cement is, in turn, surrounded by a vascular, fibrous tissue, the *periodontal membrane*, which fixes the tooth to the jaw bone. However, the tooth is not fixed rigidly to jaw bone but can move slightly during chewing and biting.

THE VERTEBRAL COLUMN

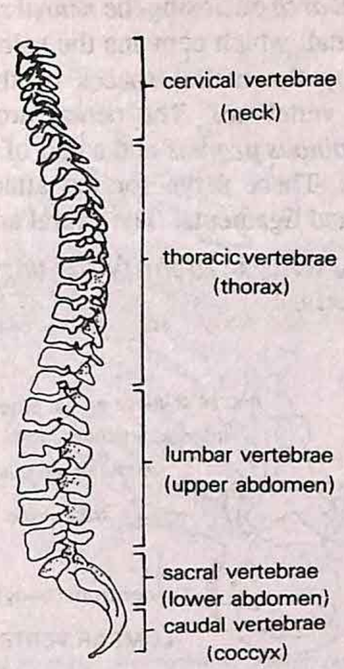


Fig. 1.10 Vertebral column of man

The vertebral column lies in the middle of the back and forms a central axis to which all the other parts of the skeleton are connected. It is made up of a number of ring-like, irregular bones. It is a flexible column consisting of thirtythree bones called *vertebrae*. The vertebral column not only provides a central support to the body, but also protects the spinal cord which runs through it. The entire column is not like a vertical rod. Some of the vertebrae are free while some are fused together. Hence, there are differences in the details of their structure.

Based on these differences, five regions can be distinguished in the vertebral column of man and other mammals. They are:

1. *The cervical region*, which consists of the seven vertebrae of the neck region.
2. *The thoracic* or *dorsal region*, which consists of the twelve vertebrae of the back region.
3. *The lumbar region* or the region of the loins, which consists of five vertebrae.
4. *The sacral region* which consists of five vertebrae fused into a single bone, wedged in between the two hip bones.
5. *The coccygeal region* which is made up of four imperfect vertebrae corresponding to the tail of other animals. The coccyx is attached to the sacrum.

A typical vertebra of man

A typical vertebra has a solid disc of bone called the centrum. On its dorsal side, the centrum bears the *neural arch* enclosing the *neural space*. The neural canal, which contains the spinal cord, is formed by the neural spaces of the serially arranged vertebrae. The neural arch bears a median *spinous process* and a pair of transverse processes. These serve for the attachment of muscles and ligaments. The neural arch of each vertebra has two pairs of articulating facets, one above and one below, at the base of the transverse processes, where adjacent vertebrae articulate.

Between the centres of adjacent vertebrae there are pads of cartilage called *intervertebral discs*. They serve as cushions for absorbing shocks.

Activity 6: *Identify the various parts of a typical vertebra, atlas and axis.*

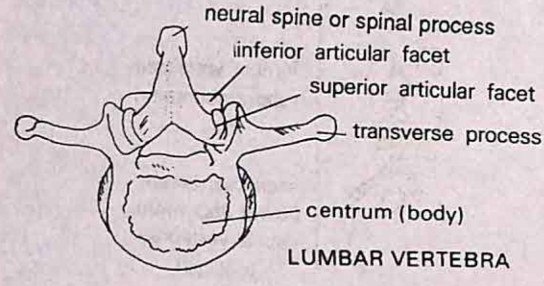


Fig. 1.11 A typical vertebra of man

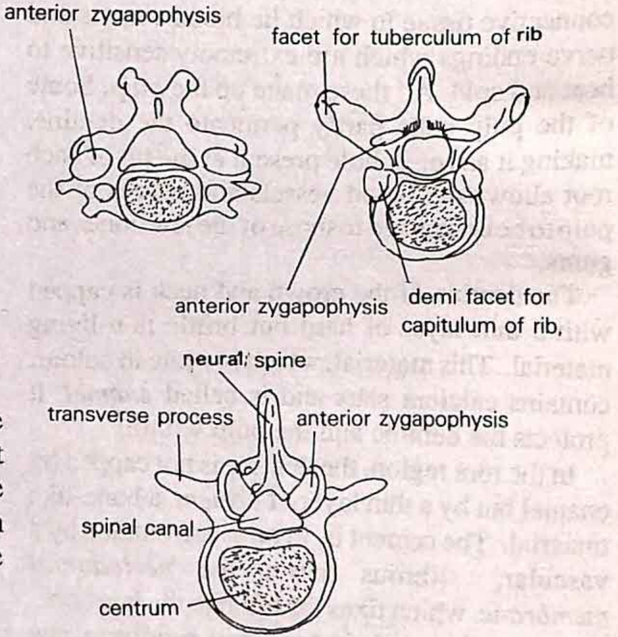


Fig. 1.12 Representative vertebrae, all in anterior (front) view

Atlas and axis: The first vertebra is called the *atlas*, as it bears the head. It has no centrum, but has very large transverse processes on which the condyles rest (on either side of the foramen magnum is a projection, termed a condyle) of the skull. This joint allows the head to nod.

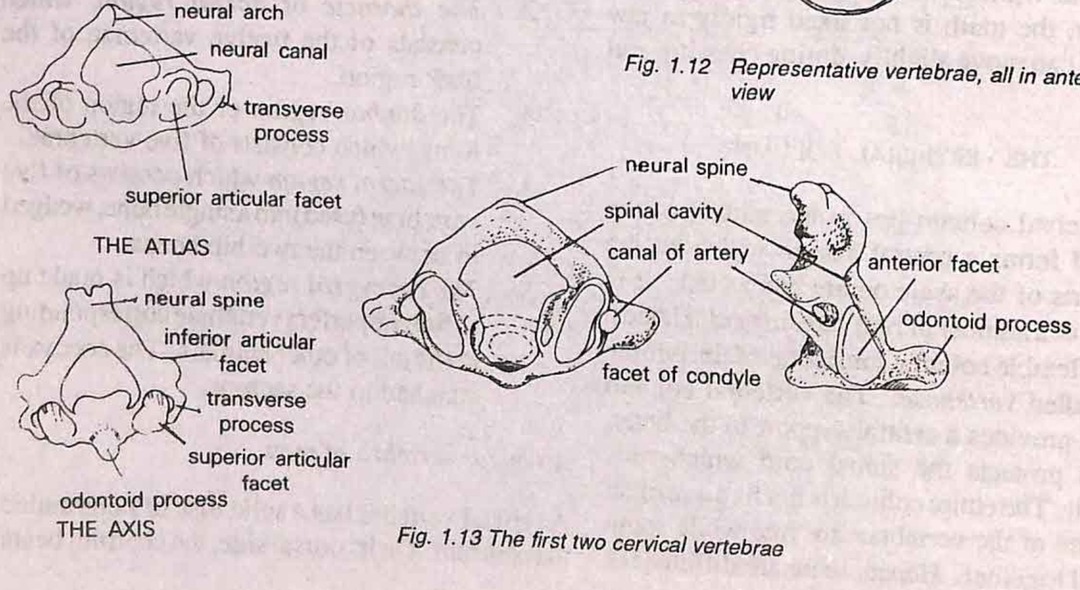


Fig. 1.13 The first two cervical vertebrae

The second vertebra is the *axis*, which has a peculiar peg-like structure projecting forward from its centrum. This allows the head and atlas to turn, since the peg of the axis fits into the hole caused by the lack of the centrum in the atlas. These two vertebrae, and all the rest of the cervicals, are characterised by the possession of a small canal on either side of the centrum, through which an artery passes tò the brain.

RIBS AND STERNUM — THORAX

The twelve thoracic vertebrae at the back, the sternum in front and the twelve pairs of ribs on the sides form a protective framework for the thorax. The heart and the lungs are thus well protected. All twelve pairs of ribs are attached behind to the thoracic vertebrae. In front, however, the first seven pairs of ribs are joined directly to the sternum by cartilages. The eight, ninth and tenth pairs of ribs are connected with one another and jointly connected to the seventh pair. The eleventh and twelfth pairs do not join the sternum and are free. The first seven pairs of ribs are called *true ribs* and the remaining five pairs are called *pseudo* or *false ribs*. The last two pairs (11th and 12th) are called *floating ribs*.

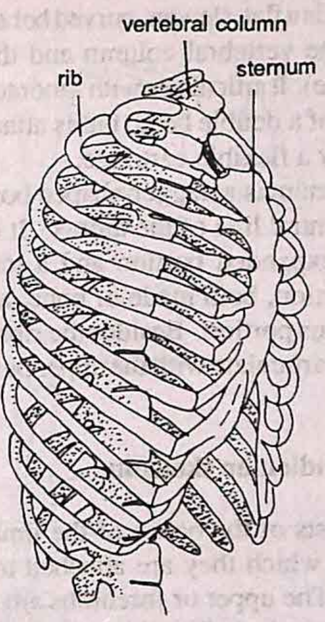


Fig. 1.14 The rib cage, with vertebral column and sternum (side view)

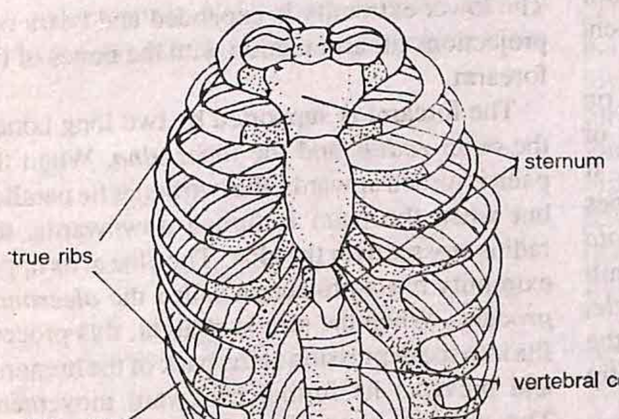


Fig. 1.15 The rib cage (front view)

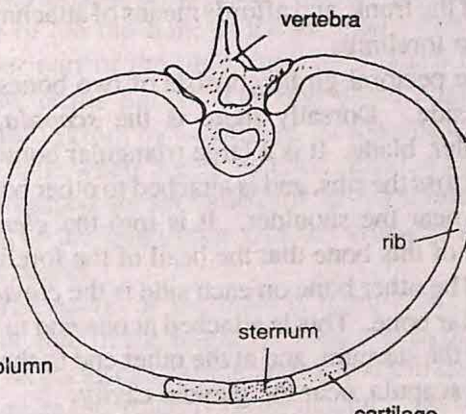


Fig. 1.16 Articulation of a pair of ribs with a vertebra and the sternum

Each rib is a flat, slender, curved bone extending between the vertebral column and the sternum (breast bone). It articulates with a thoracic vertebra by means of a double head, but is attached to the sternum by a flexible cartilage.

The sternum is a dagger-shaped bone lying in the mid-ventral line of the thorax. It consists of an upper expanded portion and a long narrow middle portion, both made of bone, and a small cartilaginous portion. Besides the ribs, the collar bones also articulate with the upper portion of the sternum.

The appendicular skeleton

This consists of the bones of the limbs and the girdles by which they are attached to the axial skeleton. The upper or forelimbs are connected to the *pectoral girdle,* while the lower or hind limbs are connected to the *pelvic girdle.*

PECTORAL GIRDLE AND FORELIMBS OR UPPER EXTREMITY

In lower animals (e.g. frog), the pectoral girdle, as its name implies, is an almost complete hoop. It forms a support for the body wall at the anterior end of the trunk, and affords means of attachment for the forelimbs.

The pectoral girdle consists of two bones on each side. Dorsally there is the *scapula,* or shoulder blade. It is a large triangular bone. It lies across the ribs, and is attached to other bones only near the shoulder. It is into the *glenoid cavity* of this bone that the head of the forelimb fits. The other bone on each side is the *clavicle,* or collar bone. This is attached at one end to the top of the sternum, and at the other end to the tip of the scapula, near the glenoid cavity.

The upper arm, the forearm, the wrist, the palm and the fingers of the upper limbs are supported by distinct bones. Supporting the upper arm is a single bone, the *humerus.* It is a long bone with its upper extremity ending in a spherical head that fits into the glenoid cavity.

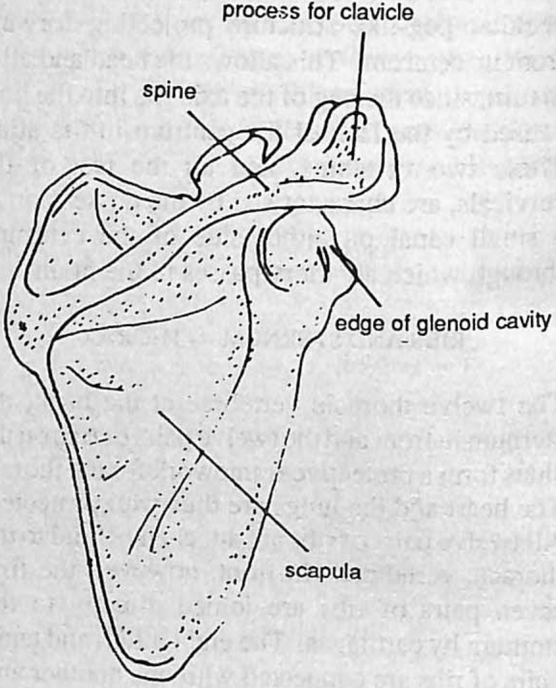


Fig. 1.17 The right scapula from behind

The lower extremity is expanded and bears two projections for articulation with the bones of the forearm.

The forearm is supported by two long bones, the outer *radius* and the inner *ulna.* When the palm is turned upwards, the two bones lie parallel, but when the palm is turned downwards, the radius crosses over the ulna. The ulna at its upper extremity has a projection called the *olecranon process.* When the arm is straight, this process fits into the depression at the back of the humerus and prevents its further backward movement. The wrist is supported by eight small bones called *carpals,* arranged in two rows of four. The palm is supported by five, long, slender bones called *metacarpals.* The fingers consist of fourteen pieces of bone called *phalanges,* of which two are found in the thumb and three in each of the remaining fingers.

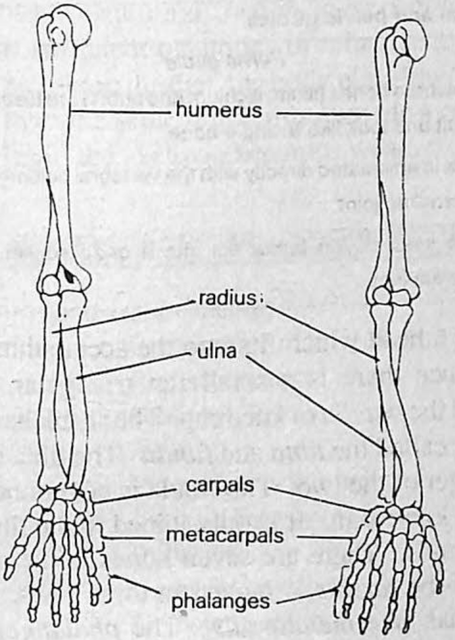


Fig. 1.18 The bones of the right arm

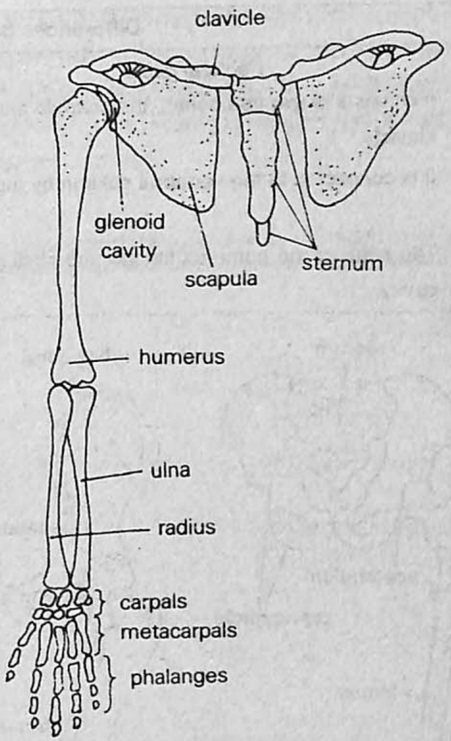


Fig. 1.19 Pectoral girdle and bones of the right upper limb

PELVIC GIRDLE AND BONES OF THE HIND LIMBS OR LOWER EXTREMITY

The pelvic girdle and sacrum together form a complete ring of bone, known as the *pelvis*, in the region of the hips. Each hip bone is formed of three bones, which are distinct in the young, but get fused in the adult. The upper broad, flat part of the hip bone is the *ilium*. The thick lower back part of the hip bone is the *ischium*. The front lower part of the hip bone, the smallest of the three, is the *pubis*. The two pubic bones are joined in front by a cartilage. At the side of each hip bone where the three bones meet, there is a cup-shaped socket called the *acetabulum*. The head of the thigh bone (femur) articulates with this socket.

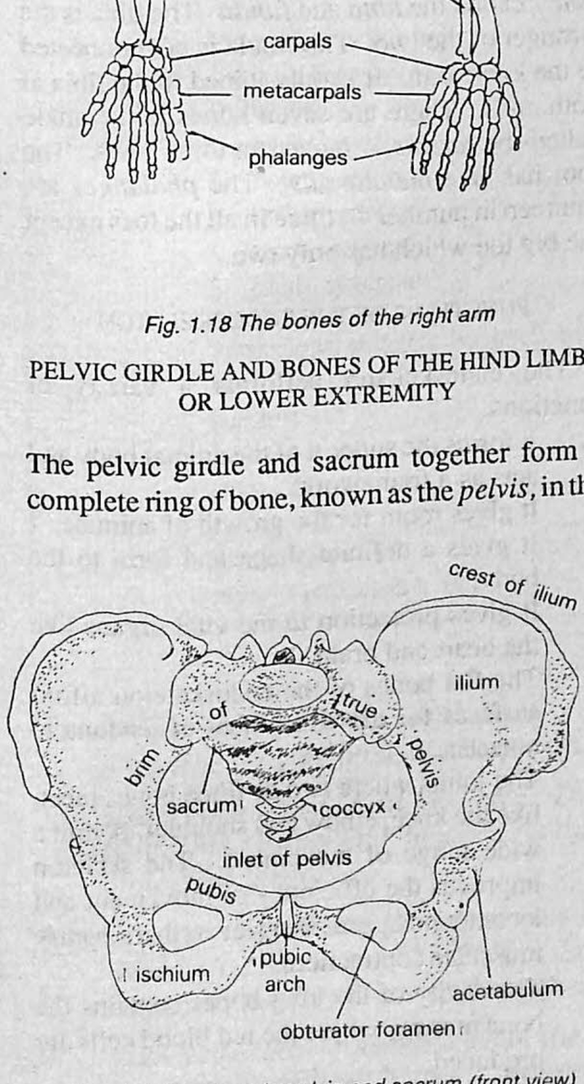


Fig. 1.20 The female pelvis and sacrum (front view)

The pelvis of the male is narrow but heavy while that of the female is wide and light. The pelvis encloses a circular area in the female but in the male it is roughly heart-shaped. The sacrum of the male is also longer and curved but is broad and straight in the female.

The lower limb, too, has five divisions, namely the thigh, the shank, the ankle, the foot and the toes. The thigh is supported by a long bone called the *femur*. This is the longest bone in the body.

Differences between the pectoral and pelvic girdles

	Pectoral girdle	*Pelvic girdle*
1.	It consists of two free bones, the scapula and the clavicle	The three bones (ilium, ischium and pubis) are fused in the adult and look like a single bone.
2.	It is connected to the vertebral column by muscles.	This is articulated directly with the vertebral column by the sacro-iliac joint.
3.	The head of the humerus fits into the shallow glenoid cavity.	The head of the femur fits into a deep socket called acetabulum.

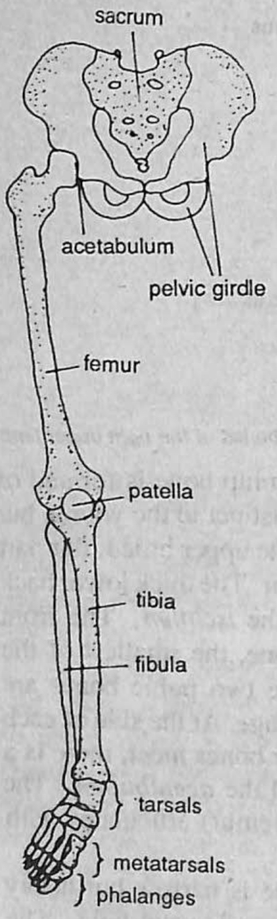


Fig 1.21 Pelvic girdle and bones of the right lower limb

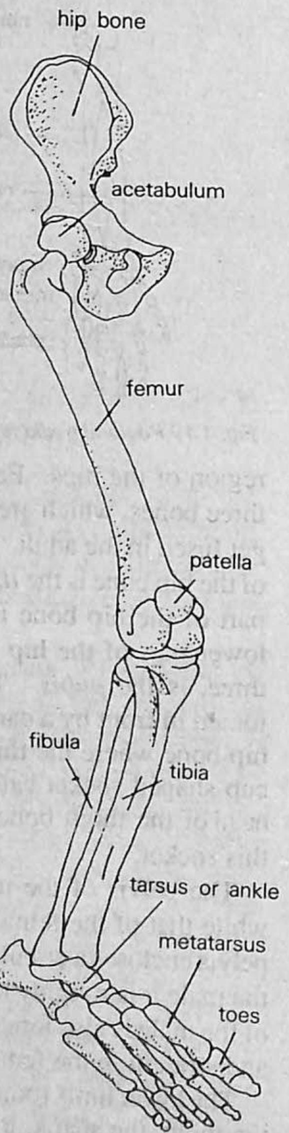


Fig. 1.22 The bones of the right leg

It has a head which fits into the acetabulum. At the knee there is a small flat triangular bone called the *patella* or knee cap. The shank has two bones called the *tibia* and *fibula*. The tibia is the stronger of the two. The fibula is not connected to the knee joint. It is only joined to the tibia at both ends. There are seven bones in the ankle called the *tarsals*, arranged in three rows. The foot has five *metatarsals*. The *phalanges* are fourteen in number — three in all the toes except the big toe which has only two.

FUNCTIONS OF THE ENDOSKELETON

The endoskeleton performs a variety of functions.

1. It forms the support of the animal body and acts as a framework.
2. It gives room for the growth of animals.
3. It gives a definite shape and form to the body.
4. It gives protection to the vital organs like the heart and brain.
5. The flat bones of the endoskeleton afford surfaces for the attachment of tendons to muscles.
6. The joints where two or three bones meet, like the knee, elbow and shoulder, permit a wide range of movement. The skeleton improves the efficiency of movement and locomotion by providing levers that magnify muscular contraction.
7. The cavity of the long bones contains the bone marrow where the red blood cells are produced.

8. The skeleton is also a storehouse of minerals. If sufficient quantities of minerals are not present in the diet, the body may draw them from the skeleton. If this exceeds a certain limit, the skeleton becomes weak.

9. The skeleton also plays an important part in respiration. The rib cage contributes to the breathing mechanism by continuously increasing and decreasing the volume of the thoracic cavity.

Some basic concepts

The exoskeleton: eg. feathers, scales, hoofs.

The endoskeleton

Axial skeleton

The skull

1. The cranium — 8 bones
2. The facial bones — 14 bones.

The vertebral column.

1. cervical vertebrae — 7
2. thoracic vertebrae — 12
3. lumbar vertebrae — 5
4. sacral vertebrae — 5
5. caudal vertebrae — 4

Appendicular skeleton: Two forelimbs and two hind limbs.

forelimb — (arm)	hind limb (leg)
humerus — 1	femur — 1
radius — 1	tibia — 1
ulna — 1	fibula — 1
carpals — 8	tarsals —7
metacarpals — 5	metatarsals — 5
digits — phalanges 14	digits — phalanges — 14

Some suggested projects / activities

1. *Examine a large bone of sheep. Cut the bone transversely and identify the parts.*
2. *Examine a pond snail and crab. Draw figures and label the parts. Refer books to do this. Take your teacher's help to learn the Latin / Greek names and biological terms.*
3. *Observe the exoskeleton of various animals such as scales of fishes, garden lizard etc., feathers of birds, fur, hair, horns and hoofs of various animals. Write a note on the functions of these (besides protection).*
4. *Visit your local museum. Note the differences in the arrangement and proportions of limb bones in mammals which move in different ways.*

REVISION

I Answer the following:

1. What are the kinds of tissues which help mammals to adapt themselves to terrestrial environment?
2. Name the exoskeleton of fish, eagle and gorilla.
3. What do you mean by the terms exoskeleton? How is it useful?
4. Describe the structure of a tooth as seen in a longitudinal section.
5. Describe the pelvic girdle and the bones of the lower limb.
6. What are the functions of the skeleton? What is the significance of the skeleton?
7. Name eight bones and state their exact location in your body.
8. What are the groups into which all the bones of your body are arranged? Briefly state the function of each group.
9. Describe the structure of the vertebral column and its importance in the structure of the human body.
10. Draw a neat labelled diagram of the pentadacty! plan of human limb.
11. What is the difference between milk and permanent teeth? Why is it better that young mammals do not have teeth when they are born?
12. How can the growth of teeth be corrected? Why is this important?
13. Many people oppose the adding of fluoride to drinking water which some scientists think would decrease the amount of dental caries (decay). Think of as many arguments as you can as to why people oppose this.

II Choose the correct answer

1. Our bodies are supported by an internal framework of bones called
   a. endoskeleton. b. axial skeleton. c. appendicular skeleton. d. exoskeleton.
2. The only movable bone in the skull is the
   a. maxilla. b. mandible. c. ethmoid. d. occipital.
3. The bulk of the tooth consists of a hard substance called
   a. dentine. b. pulp cavity. c. cement. d. enamel.
4. Molars usually possess
   a. only one root. b. more than one root. c. no root at all. d. partial root.
5. The depression into which the upper arm bone fits is called
   a. scapula. b. clavicle. c. glenoid cavity. d. acetabulum.
6. The name of the upper arm bone is
   a. ulna. b. humerus. c. femur. d. radius.
7. The wrist bones are known as
   a. metatarsals. b. metacarpals. c. carpals. d. tarsals.
8. The number of bones in the tarsal region is
   a. five. b. seven. c. fourteen. d. eight.

9. Of the following, the bone which has a hinge joint at one end and a ball and socket joint at the other is the
a. scapula. b. femur. c. radius. d. atlas.

10. Muscles are attached to bones by means of
a. tendons. b. ligaments. c. cartilage. d. adipose tissue.

11. The forearm is supported by two bones namely the
a. radius and ulna. b. tibia and fibula. c. carpals and metacarpals. d. tarsals and metatarsals.

12. True ribs are attached to the sternum by
a. tendons. b. ligaments. c. muscles. d. cartilage.

III Distinguish between

a. atlas and axis. b. true ribs and false ribs. c. incisors and molars. d. sutures and foramen magnum. e. maxilla and mandible. f. glenoid cavity and acetabulum. g. carpals and tarsals h. tendons and ligaments. i. axial and appendicular skeletons

IV Give scientific reasons for the following:

1. The patella is fused to the tibia.
2. Finger and toe nails are not made of bone.
3. Bone marrow is fatty.
4. Bones act as levers.
5. The thumb and fingers of man can be used in apposition to each other.

V Fill in the blanks with suitable words or phrases

1. The cranium is made up of __________ bones.
2. The immovable joints on the cranium, marked by zig-zag lines, are called ________ .
3. At the back of the base of the cranium is a large opening known as ________ .
4. The dentition in man is adapted for a __________ diet.
5. A typical vertebra has a solid disc of bone called __________ .
6. The thigh is supported by a long bone called __________ .

VI Write notes on

a. functions of the skeleton. b. the pelvic girdle. c. the bones of the upper limb. d. the thoracic region. e. the skull. f. a typical vertebra. g. atlas. h. axis. i. facial bones. j. pectoral girdle. k. the bones of the lower limb.

3

2. Physiology

Human physiology - digestive system - structure and functions - study of ingestion, digestion, assimilation and digestion - respiratory system - structure of human respiratory system - significance and need - mechanism - gaseous exchange in the alveoli and tissues.

2.1 Human physiology

The functions of the various parts of the human body are studied under a branch of science known as *human physiology*. The way in which the food which we eat is digested, the part played by the blood in the body and the means whereby we draw fresh air into the lungs are examples of physiological processes.

2.2 Structure and functions of various parts of the digestive system

The digestive system is a system of organs which takes part in obtaining nourishment. This system consists of an alimentary canal and some other glands, i.e., the liver, pancreas and salivary glands.

The alimentary canal is a long coiled tube of variable diameter. It measures upto nine metres in length. The canal has two apertures for communicating with the outside. They are the mouth and anus. The mouth lies between two movable lips. It leads internally into a *mouth cavity*. Both the upper and lower jaws bear *teeth*. The lower jaw has a muscular *tongue*. The mastication of the food by the teeth aids digestion.

DIGESTION IN THE MOUTH

Three pairs of *salivary glands*, i.e., the *parotid*, *sub-lingual* and *sub-maxillary* (or *sub-mandibular*) open into the mouth cavity. Their secretion is called *saliva*. Saliva is a watery fluid which contains *ptyalin or salivary amylase*. The moistened and masticated food is rolled up into a small ball or *bolus*. It is passed into the

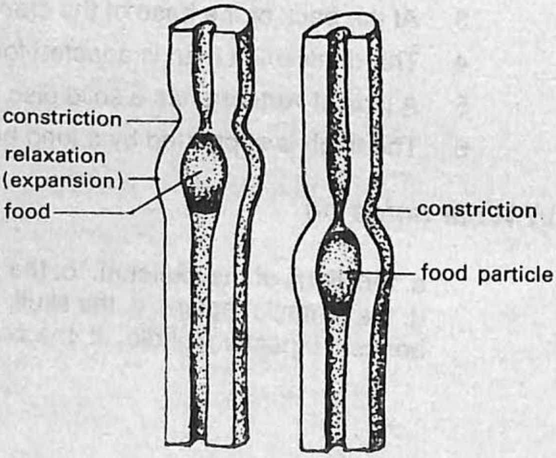


Fig. 2.1 The peristaltic movement of food

pharynx or the posterior part of the *buccopharyngeal* cavity of the tongue.

The *oesophagus* is a narrow muscular and tubular part which lies posterior to the trachea. It is about 25 cm in length and opens into the stomach after piercing the diaphragm. Passage of food through it and subsequent parts of the alimentary canal is made possible by *peristalsis* or the rhythmic contraction and expansion of the walls of the oesophagus.

Activity 1: *Take a piece of bread. Masticate it thoroughly for at least four minutes. In the beginning it does not taste sweet but within a few minutes it begins to taste sweet. This is due to the starch, which has been converted to sugar by the action of an enzyme ptyalin, present in the saliva.*

Activity 2: *Put some visking tubes (similar to cellophone), containing a solution of starch and glucose in a beaker of warm water (37°C). Test the water immediately with iodine and Benedict's solution. Test it again in 30 minutes. Explain your results.*
How do you think this is similar to the way in which the alimentary canal works?

DIGESTION IN THE STOMACH

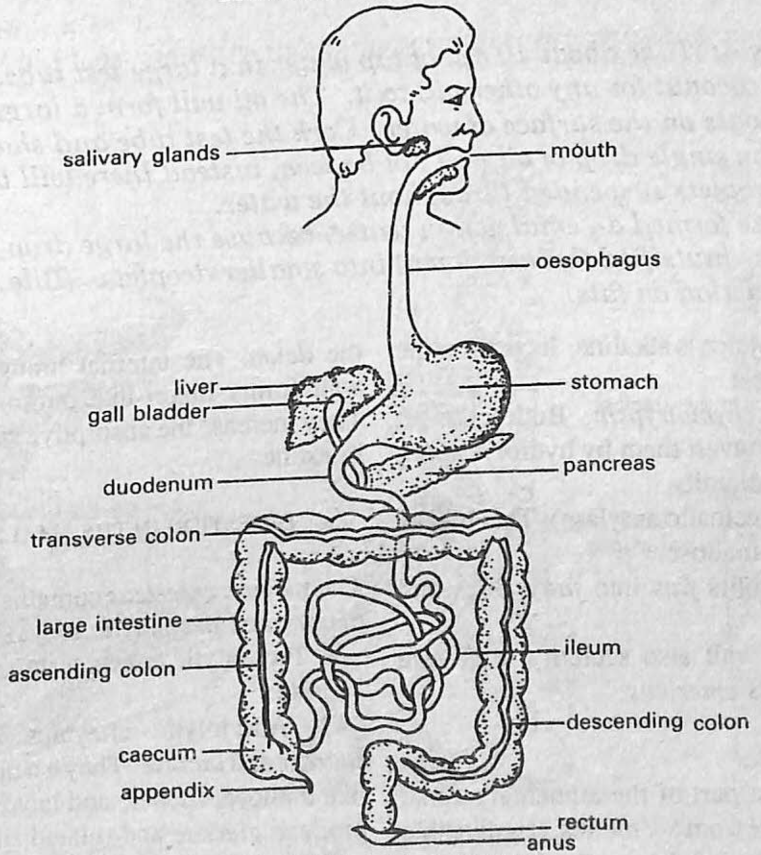


Fig. 2.2 Alimentary canal of man

The stomach is a J-shaped, wide and muscular organ which lies on the left side of the abdominal cavity behind the diaphragm.

The walls of the stomach secrete a *gastric juice* which contains hydrochloric acid and two enzymes — *pepsin* and *renin*

Hydrochloric acid : This is secreted by special cells called *oxyntic cells*. Its function is to make the medium acidic and to kill most of the bacteria taken with the food.

Pepsin: This is an enzyme which acts on proteins. Pepsin converts proteins to *peptones*.

Renin: This is another enzyme found in the gastric juice of young mammals. In the presence of calcium salts, the soluble milk protein or *caseinogen* is converted into insoluble *casein*.

In the stomach the food is mixed up with fluids and mucus. It is also churned into a semi-fluid called *chyme*. The latter is passed to the duodenum through the opening of the *pyloric sphincter*.

The *duodenum* receives two ducts, the *common bile duct*, and the *pancreatic duct*. The two ducts join together before opening into the duodenum.

The fluid from the liver is called *bile*, while that of the pancreas is *pancreatic juice*.

The bile does not possess any digestive enzymes. It possesses alkaline substances which neutralise the acidic nature of chyme. It, however, helps in emulsifying fat into small droplets.

Activity 3: *Do you know that some animals produce renin when young but not when they are older? Why is this so? Discuss your findings with your classmates.*

Activity 4: *Take about 10 ml. of tap water in a large test tube. Add 1 ml. of coconut (or any other oil) to it. The oil will form a large drop which floats on the surface of water. Cork the test tube and shake it well. The single drop of oil will not be seen, instead there will be many small droplets suspended throughout the water.*

Oil has formed an emulsion in water, because the large drop of oil has been emulsified (broken down) into smaller droplets. (Bile has a similar action on fats).

The pancreatic juice is alkaline. It contains the following enzymes:

1. *Trypsin* and *chymotrypsin:* Both these act on *proteins* and convert them by hydrolysis into *peptones* and small units.

2. *Amylase* (pancreatic amylase): This breaks down *starch* into maltose.

3. *Lipase:* It splits *fats* into *fatty acids* and *glycerol*.

The intestinal wall also secrete a digestive juice called *succus entericus*.

The small intestine

This is the longest part of the alimentary canal which may measure from 5-7 metres. It is divisible into three parts: the *duodenum*, the *jejunum* and the *ileum*. The internal lining of the intestinal wall forms finger-like outgrowths called *villi*. They increase the absorptive surface of the small intestine.

DIGESTION IN THE SMALL INTESTINE

The *succuss entericus* contains all the three types of enzymes: *proteolytic*, *amylolytic*, and *lipolytic*.

1. Proteolytic enzymes are collectively called *erepsin*

2. Amylolytic enzymes include *maltase*, *sucrase* and *lactase*. They act upon *disaccharides* like maltose, sucrose and lactose respectively to produce *glucose* and related simple sugars.

3. Lypolytic enzymes or *intestinal lipase*

complete the digestion of fats. *Fats* are converted into *fatty acids* and *glycerol*.

ABSORPTION

Absorption is the passage of digested food through living membranes. The digested food is absorbed in the small intestine.

The villi take part in this process. For this they possess *blood capillaries* and a large lymph vessel called the *lacteal*. Simple sugars and amino acids are absorbed by blood capillaries while fatty acids and glycerol are picked up by lacteal. The fluid food present in the small intestine is known as *chyle*. After losing its diffusible food particles, the chyle is passed on to the next part of the alimentary canal known as the large intestine.

THE LARGE INTESTINE

This is about 1.5 metres in length. The large intestine is divisible into four parts—the *caecum*, *colon*, *rectum* and the *anal canal.*

The caecum is a blind pouch which gives rise to a small narrow projection called the *appendix*.

The colon is distinguishable into four parts: *ascending*, *transverse*, *descending* and *sigmoid*. The ascending colon rises from the caecum and reaches upto the base of the liver.

Activity 5: ***Questions to think about:***

1. *Why do you think many people suffered from stomach ulcers during World War II.*
2. *Some people have large lunches at midday. Why is this often said to cause ulcers?*
3. *Find out why digestive juices do not digest the animal's own gut.*

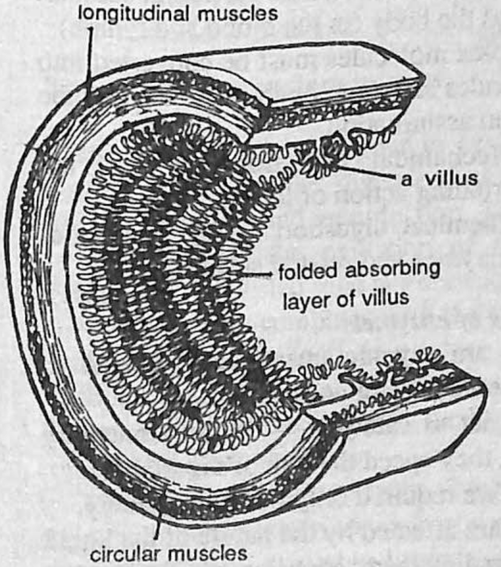


Fig. 2.3 Intestinal wall lined with villi on inner surface

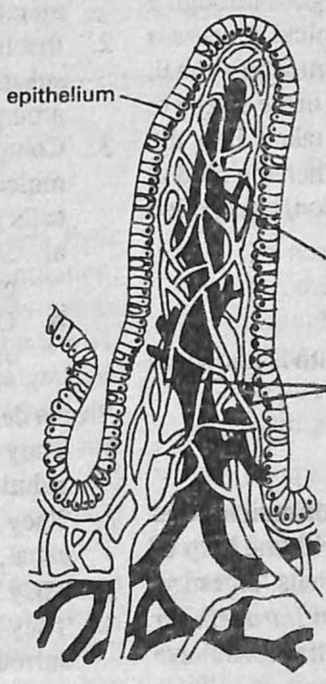


Fig. 2.4 L.S. through villus

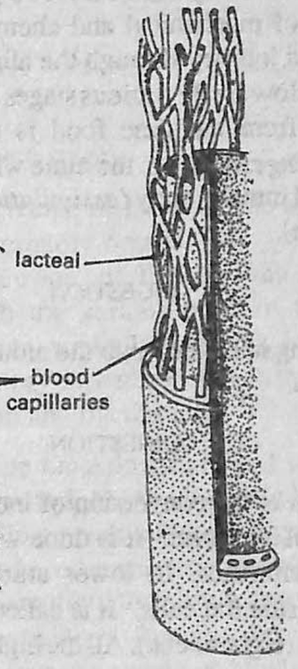


Fig. 2.5 Stereogram of villus

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Activity 6: *Prepare a model of the human digestive system with plastic, clay. Label the various parts.*

Digestion of food in human beings

Digestive glands	*Digestive juice*	*Enzymes*	*Action*
1. salivary glands	saliva	ptyalin	starch → maltose.
2. gastric glands	gastric juice with hydrochloric acid	pepsin renin	proteins → peptones coagulates milk proteins.
3. liver	bile	none	emulsifies fats.
4. pancreas	pancreatic juice	trypsinogen (trypsin) amylase lipase	peptones → amino acids (with the help of enterokinase) starch → maltose emulsified fats → fatty acids and glycerol.
5. intestinal glands	intestinal juice	enterokinase peptidase maltase invertase lactase lipase	Helps typsinogen to change peptones to aminoacids. peptones → amino acids maltose → glucose sucrose → glucose and fructose lactose → glucose and galactose emulsified fats → fatty acids and glycerol

2.3 Study of ingestion, digestion, assimilation and egestion

You have already seen that food goes through a number of mechanical and chemical processes during its journey through the alimentary canal. Given below are the various stages of the digestive process from the time food is taken into the mouth *(ingestion)* to the time when the food is absorbed into the body *(assimilation)* or expelled *(egestion).*

INGESTION

The taking in of food into the mouth is known as *ingestion.*

DIGESTION

Digestion is the conversion of indiffusible food into diffusible form. It is done with the help of various enzymes. In lower animals digestion occurs inside the cells. It is called *intracellular* digestion (e.g.amoeba). All the high animals have a definite digestive tract in which *extracellular* digestion takes place.

Why digestion is necessary:

1. Large molecules must be broken down into molecules small enough to permeate living membranes.
2. Insoluble substances must be changed into substances which can be carried in solution around the body (in the blood and lymph).
3. Complex molecules must be converted into molecules simple enough to be used by the cells in assimilation.
    a. Mechanical digestion — e.g. the grinding action of teeth,
    b. Chemical digestion — by the use of enzymes and related substances.

Properties of enzymes.

1. They are organic chemicals, secreted in solution by living cells.
2. They act as catalysts — in the alimentary canal, they speed the rate of digestion.
3. They are required only in small quantity.
4. They are affected by the nature of the liquid surrounding them; each enzyme works most efficiently at a certain degree of acidity or alkalinity.

5. They are affected by temperature.
6. They are specific, i.e., each enzyme will act upon only one type of substance.

ASSIMILATION

The nutrients absorbed into the blood in the form of simple molecules are eventually transported to the cells. The cells utilise these products of digestion as a source of energy or to make more protoplasm. The utilisation of nutrients by the cells is termed *assimilation*.

EGESTION

Egestion is the expulsion of undigested food materials. The semi-solid faecal matter is passed into the rectum when a man feels the urge for *defecation*. The rectum leads into a small anal canal which is not more than 3 cm in length. The anal canal opens on to the outside, the aperture is known as the *anus*. The opening of the anus is guarded by *sphincter muscles*. When the pressure of the contents increase, the anal sphincter sends stimuli to the central nervous system which leads to the elimination of faeces.

The processes briefly outlined are as follows:

Ingestion
(the taking-in of food, which has usually been searched for and/or 'captured')
↓
Digestion
(the breaking down of ingested food)
↓
Absorption
(the passage of digested food through living membranes)
↓
Assimilation
(the build-up of absorbed food and its incorporation into animal cell components)
↓
Egestion
(the expulsion of undigested food materials)

Activity 7: *Find out more about the following nutritional disorders. How can you correct them? — (rickets, osteomalacia, hyponatremia, hypokalemia, kwashiorkor and marasmus)*

Activity 8: *Prepare a poster to distinguish between malnutrition and undernutrition.*

The respiratory system in man

Cells require energy in order to perform their various functions like digestion, assimilation, growth, excretion and reproduction. This energy is derived from the oxidation of foodstuffs. Oxidation of digested food is a chemical process in which oxygen combines with the carbon and hydrogen found in food, to produce water and carbon dioxide. During the process, heat and energy are released to carry on the life activities of all the cells in the body.

The term respiration refers to all the processes by which cells take in oxygen, convert energy into biologically available forms such as ATP (adenosine triphosphate), and give off carbon dioxide. The process of respiration, may be divided into three stages.

1) the exchange of gases by the surface of the respiratory organs.
2) the transport of the respiratory gases through the various parts of the body carried by a circulating fluid, and
3) respiratory exchange between the internal medium and the tissues.

The complete breakdown of food to carbon dioxide, water and energy is called *aerobic respiration*. This needs oxygen from the air. When our muscle cells cannot get enough oxygen for aerobic respiration, they breakdown food by *anaerobic respiration*. But this provides only 0.05% of the energy provided by the aerobic respiration.

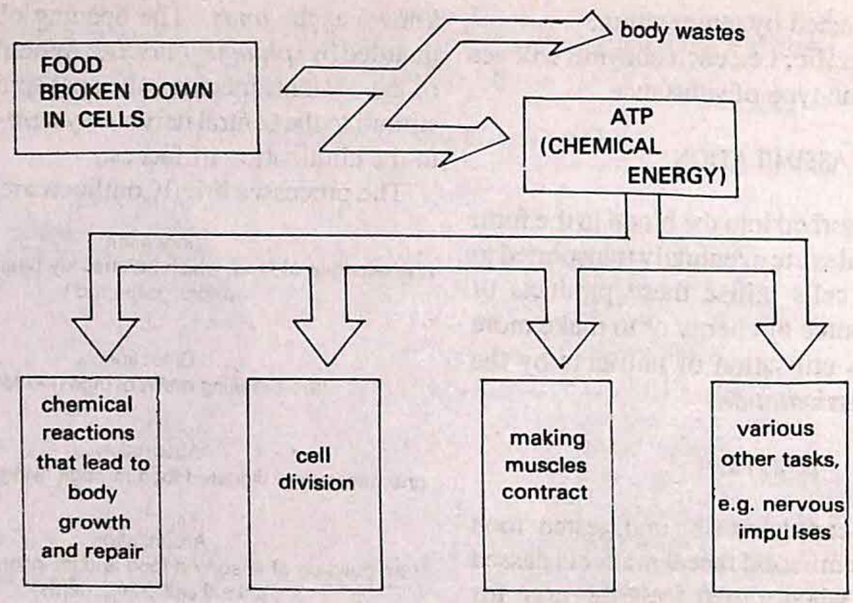


Fig. 2.7 ATP is used to make the cells work. It provides energy for chemical reactions in the body

THE RESPIRATORY SYSTEM

The respiratory system comprises of organs which take part in the exchange of oxygen and carbon dioxide between the body and the atmosphere. Respiration takes place in two parts –*external respiration* and *internal respiration.* In external respiration exchange of gases takes place at the pulmonary membranes between the blood and the atmosphere. In internal respiration this exchange occurs between the blood and the cells of the body.

In simple animals such as the protozoans, exchange of gases occurs at the general body

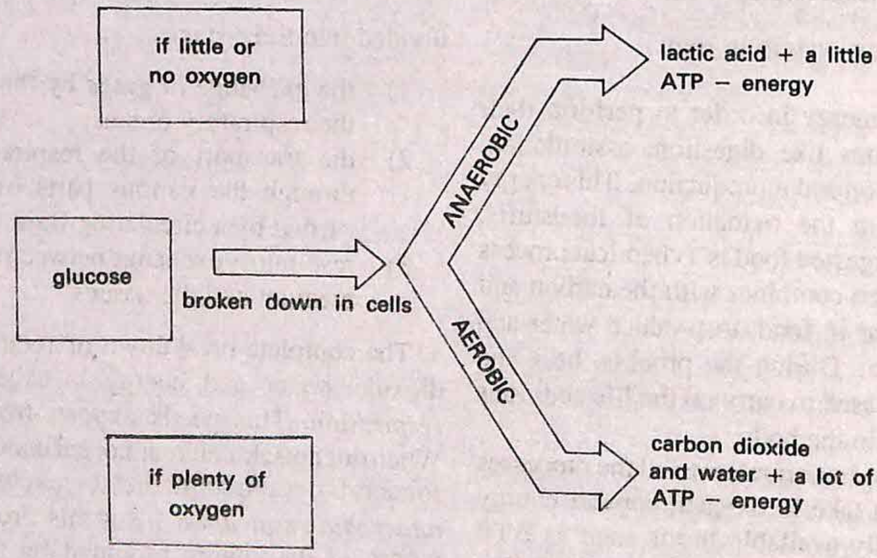


Fig. 2.8 Two forms of respiration

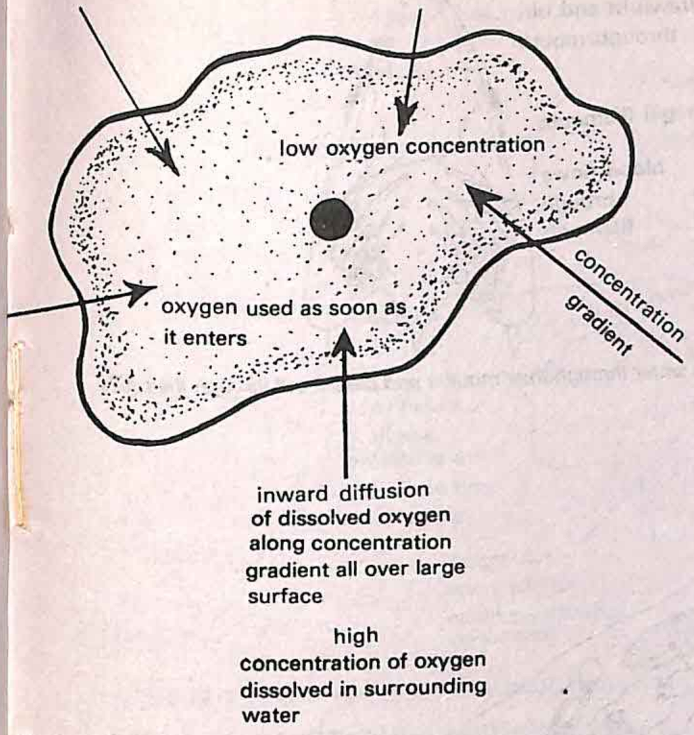

low oxygen concentration
oxygen used as soon as it enters
concentration gradient
inward diffusion of dissolved oxygen along concentration gradient all over large surface
high concentration of oxygen dissolved in surrounding water

Fig. 2.9 Respiration in amoeba (diffusion)

surface. Since diffusion is a very slow process, respiration by this method will not be sufficient to cope with the oxygen requirements of the bodies of higher animals. Hence, in all animals from annelids upwards a transport system, composed of blood vessels and a heart of some kind, is present to drive the circulating medium, namely the blood, round the body. Four main types of respiratory mechanisms are seen in the animal kingdom, namely:

1. Integumentary or cutaneous respiration.
2. Gill or branchial (aquatic) respiration.
3. Lung or pulmonary respiration.
4. Tracheal respiration.

The respiratory system in man also performs, some accessory functions like smelling, speech, coughing and sneezing. The external respiration consists of a respiratory tract for conducting air between the lungs and the outside.

2.5 Structure of the human respiratory system

The respiratory tract consists of external nares, nasal cavity, pharynx, larynx, trachea, bronchi and lungs.

External nares or nostrils are the two anterior openings of the respiratory tract. They lead internally into a nasal cavity. The nasal cavity is divided into two chambers by a *vertical partition* or *septum.* The anterior part of each nasal chamber or *fossa* is called the *vestibule.* It is lined with hair which filters out the larger particles in the incoming air. The rest of the nasal cavity is lined with a ciliated and glandular *epithelium.* The cilia and the mucous of this epithelium remove the remaining particles. Mucous additionally

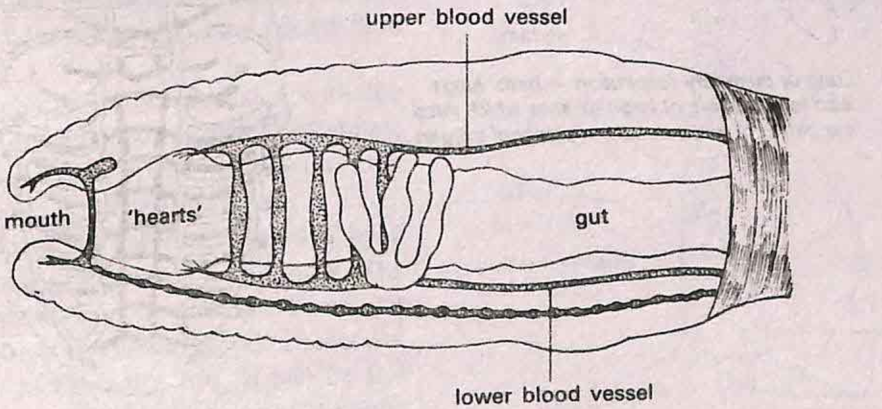


Fig. 2.10 Integumentary respiration — oxygen reaches an earthworm's blood through its skin

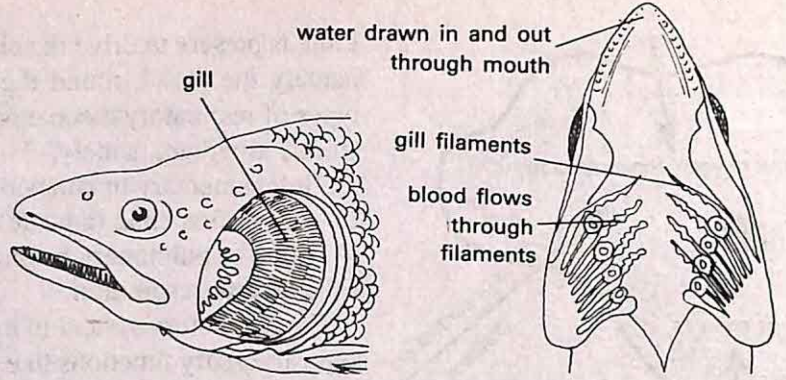


Fig. 2.11 Gill or bronchial respiration — fishes take in water through their mouths and pass it out through their gills

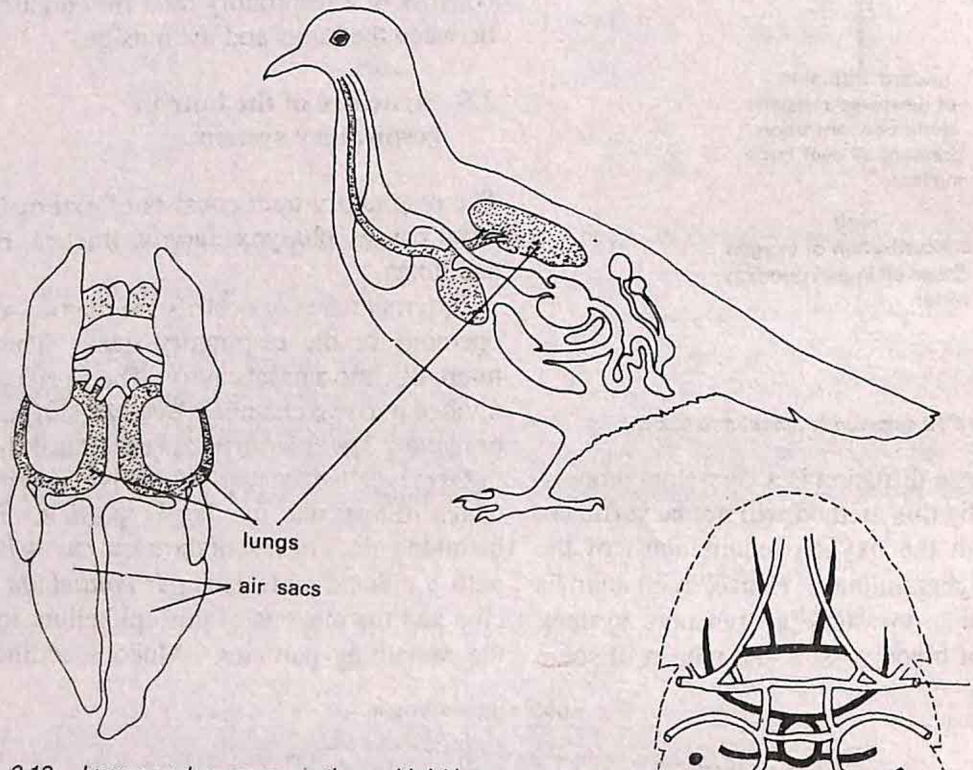


Fig. 2.12 Lung or pulmnary respiration — birds' lungs lead to a network of large air sacs which keep the bird light and can take in plenty of oxygen

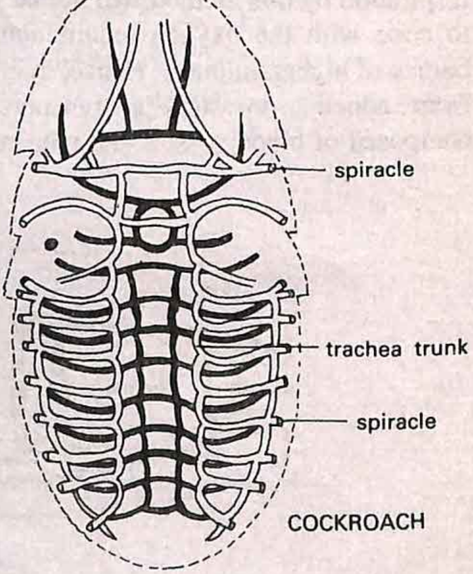


Fig. 2.13 Tracheal respiration

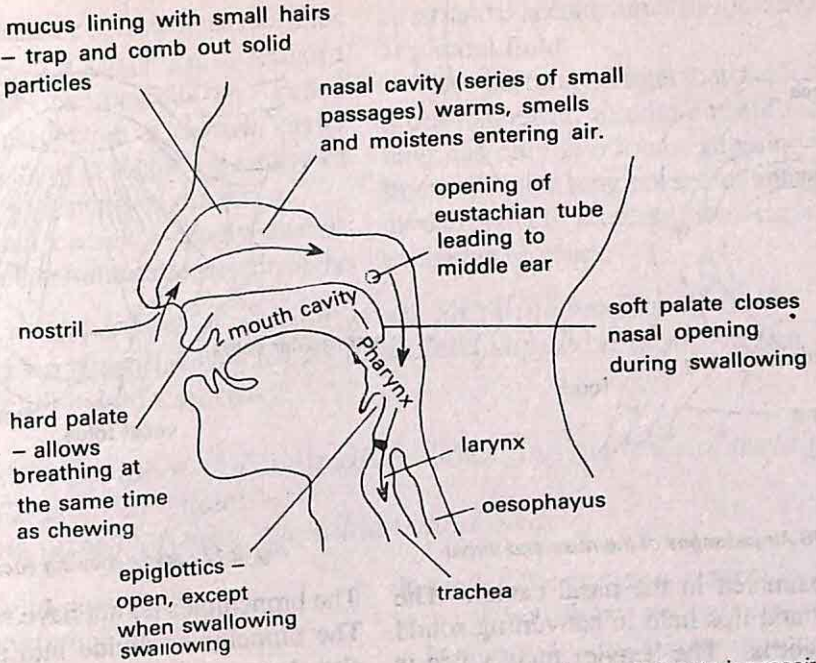

mucus lining with small hairs – trap and comb out solid particles
nasal cavity (series of small passages) warms, smells and moistens entering air.
opening of eustachian tube leading to middle ear
soft palate closes nasal opening during swallowing
nostril
mouth cavity
Pharynx
hard palate – allows breathing at the same time as chewing
larynx
oesophayus
epiglottics – open, except when swallowing swallowing
trachea

Fig. 2.14 Diagram of vertical section through head of man, showing normal pathway of air entering respiratory system

moistens the air. The blood capillaries present in the nasal lining function as air conditioners. They change the temperature of the air to the level of our body. (The nasal cavity functions in *phonation* by acting as a resonator. This is why when a person has a bad cold he loses his natural voice.)

The nasal cavity opens posteriorly into the *nasal pharynx* through openings called *posterior* (internal) *nares* or *choanae*. The nasal pharynx lies above the soft palate and receives the openings of the Eustachian tubes. (The nasal pharynx contains adenoid tissue which may get swollen due to infection.)

The nasal pharynx communicates with the larynx through the oral pharynx and the laryngeal pharynx. The oral pharynx contains two *tonsils* which may swell up due to infection.

The opening of the larynx is guarded by a flap-shaped structure called the epiglottis. The epiglottis closes the opening of the larynx or glottis at the time of swallowing food. The larynx is also known as the *voice box*. It can be felt anteriorly in the neck region as a prominence called the Adam's apple. The larynx possesses two *vocal cords* which can be stretched or loosened by means of muscles.

Sound is produced when the vocal cords are stretched and they lie near each other. The sound

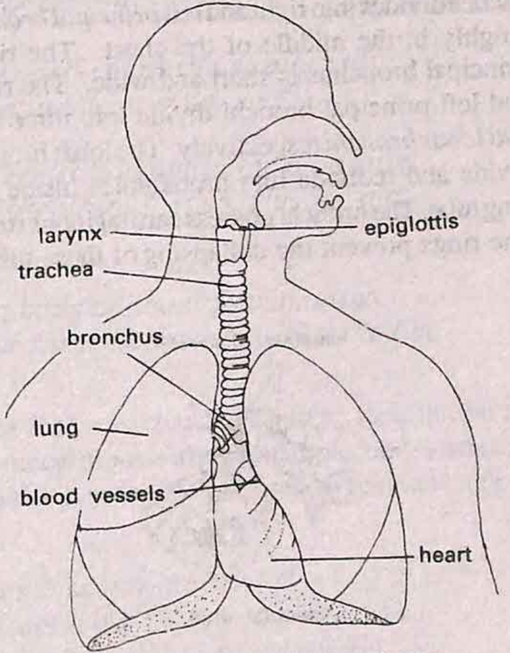


Fig. 2.15 Position of the lungs in man

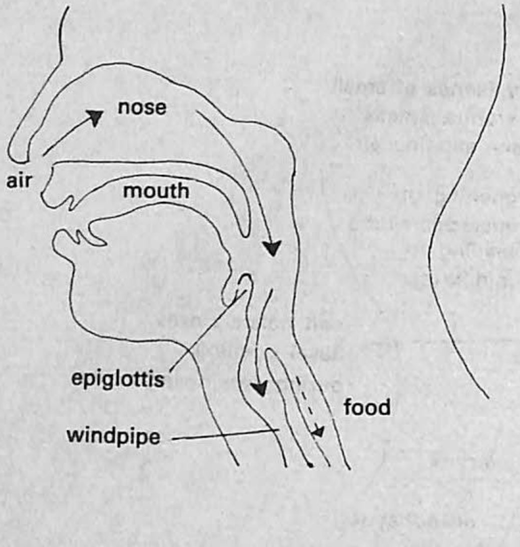


Fig. 2.16 Air passages of the nose and throat

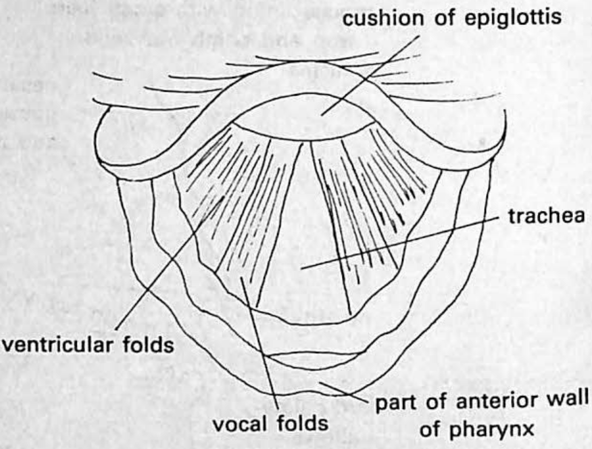


Fig. 2.17 Larynx showing vocal cords at rest.

waves are resonated in the nasal cavity. The tongue, teeth and lips help in converting sound waves into words. The heavier male voice is caused by the enlargement of the larynx and the thickening of the vocal cords due to sex hormones.

The larynx opens into the wind pipe or *trachea.* The trachea is a tube about 10-11 cm long. It is supported by C-shaped cartilaginous rings. The trachea divides into right and left *principal bronchi* roughly in the middle of the chest. The right principal bronchus is short and wide. The right and left principal bronchi divide into three and two *lobar bronchi* respectively. The lobar bronchi divide and redivide into bronchioles inside the lung tube. The bronchi possess cartilaginous rings. The rings prevent the collapsing of these tubes.

The bronchioles do not have cartilaginous rings. The bronchioles divide into *alveolar sacs.* An alveolar sac is a bunch of small pouches called *alveoli* or *air sacs.* The wall of an alveolus is thin. It possesses a network of blood capillaries for the exchange of gases.

There are two *lungs* situated in the thoracic cavity. The lungs are cone-shaped spongy

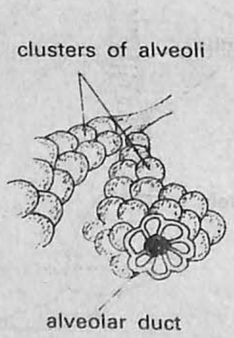
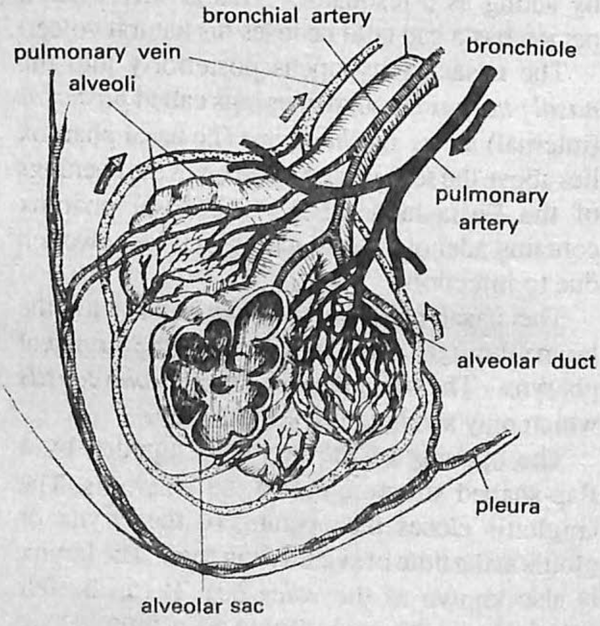


Fig. 2.18 Alveoli



Internal structure of alveoli

structures which have their apices or narrow ends directed towards the top. Each lung is surrounded by a double-walled membranous sac called *pleuron*. The pleura contain a narrow cavity (pleural cavity) filled with a small quantity of fluid for allowing movements of the lungs.

Infection of pleura causes a deadly disease named *pleurisy*, which produces acute pain in the chest, and is accompanied by increased production of pleural fluid.

The right lung is larger than the left. It has three lobes—superior, middle and inferior. The left lung has only two lobes, superior and inferior. Internally each lung possesses a large number of alveoli which increase the surface area for exchange of gases.

Activity 9: *Get a lung of a sheep/goat. Examine sections of lung tissues (to see alveoli, bronchioles and blood supply) and of trachea (to see cartilage) microscopically.*

Activity 10: *Compare and contrast the breathing methods of a range of animals as given below:*
protozoans, insects, fishes, amphibians and birds

2.6 Significance and need for the respiratory system

The food we eat is needed for a number of functions, in addition to providing for the growth of cells. For instance, our body needs energy to do work. The energy is present in a stored form in the carbohydrates and fats that we eat.

In order to do work this energy must be released. Respiration is a basic process which occurs to provide energy for all the work to be done in an organism.

Activity 11: *Close your nose and mouth for some time. How do you feel? Which part of your body is meant for the entry of air?*

Activity 12: *Sit quietly for a few minutes and count the number of inhalations and exhalations you carry on in one minute.*

Run for a minute, count your rate of respiration again for a minute. Do you find any difference in the rate of breathing? If so, give reasons for what happens.

Count the number of inspirations in a baby of about four months. Count this in your own case. Account for the difference between the two rates.

One of the immediate needs of larger animals including man (which have a high rate of oxygen consumption) is to obtain enough of oxygen to sustain life. The *lungs* provide a huge surface area for the exchange of gases. Respiration is a chemical process in which simple food substances, chiefly glucose are oxidised to release energy.

Activity 13: *Place about ten earthworms inside a thermos flask. Fix a sensitive thermometer through the cork, covering its mouth. Read the temperature for the next few hours. Account for your observations.*

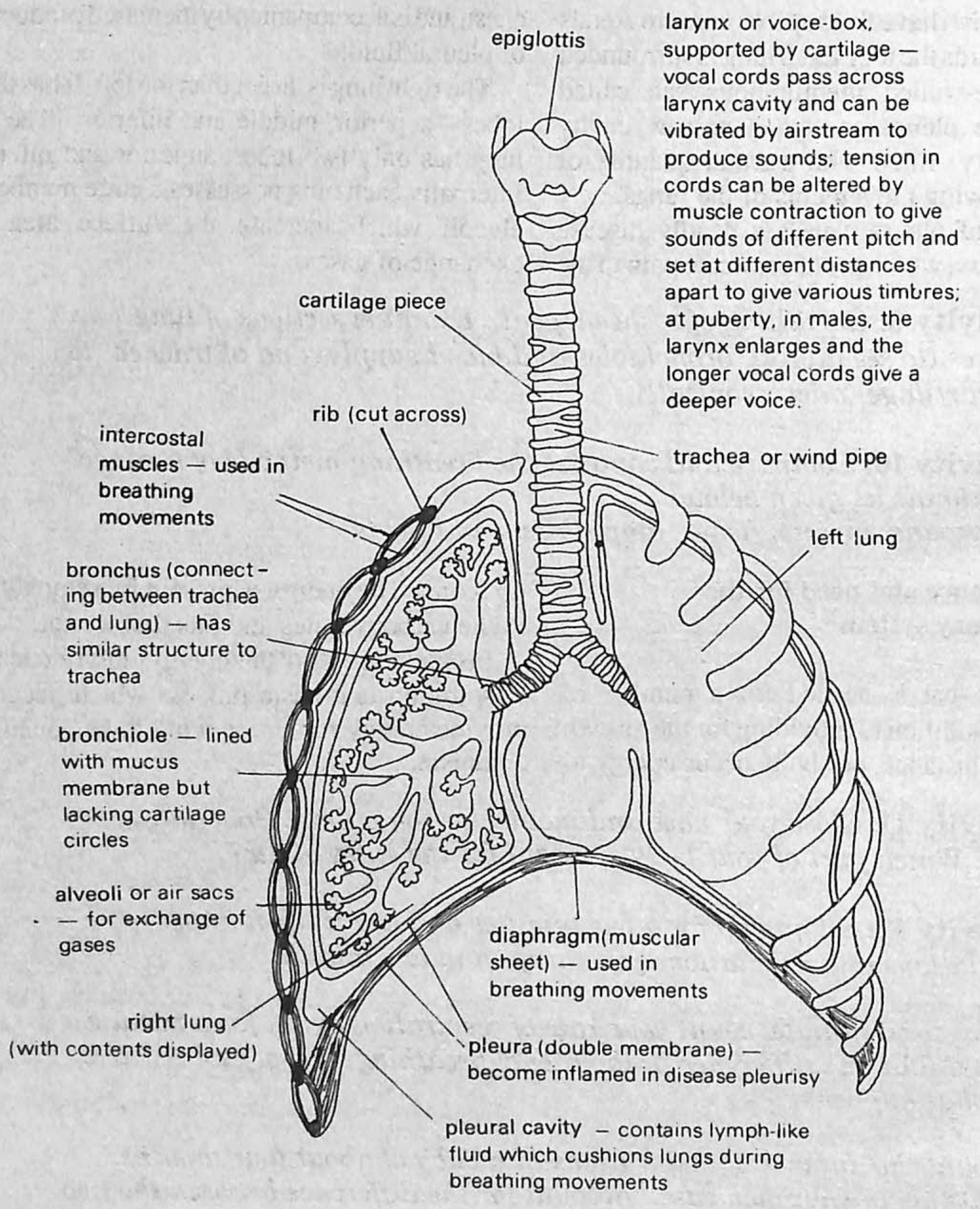

epiglottis
larynx or voice-box, supported by cartilage — vocal cords pass across larynx cavity and can be vibrated by airstream to produce sounds; tension in cords can be altered by muscle contraction to give sounds of different pitch and set at different distances apart to give various timbres; at puberty, in males, the larynx enlarges and the longer vocal cords give a deeper voice.
cartilage piece
rib (cut across)
intercostal muscles — used in breathing movements
trachea or wind pipe
left lung
bronchus (connecting between trachea and lung) — has similar structure to trachea
bronchiole — lined with mucus membrane but lacking cartilage circles
alveoli or air sacs — for exchange of gases
diaphragm(muscular sheet) — used in breathing movements
right lung (with contents displayed)
pleura (double membrane) — become inflamed in disease pleurisy
pleural cavity — contains lymph-like fluid which cushions lungs during breathing movements

Fig. 2.19 Diagram showing respiratory structures in man

Mechanism of respiration

The thorax is a completely closed chamber which communicates with the outside through the mouth and the nostrils. The series of movements which occur in order to effect inspiration and expiration is known as the *mechanism of respiration.*

The process of breathing includes the taking in of fresh air rich in oxygen into the lungs(*inhalation* or *inspiration)* and the giving out of air (rich in carbon dioxide) from within the lungs, *(exhalation* or *expiration.)* Inhalation and exhalation take place at the rate of 15-20 times per minute in an adult person who is at rest. It depends upon the

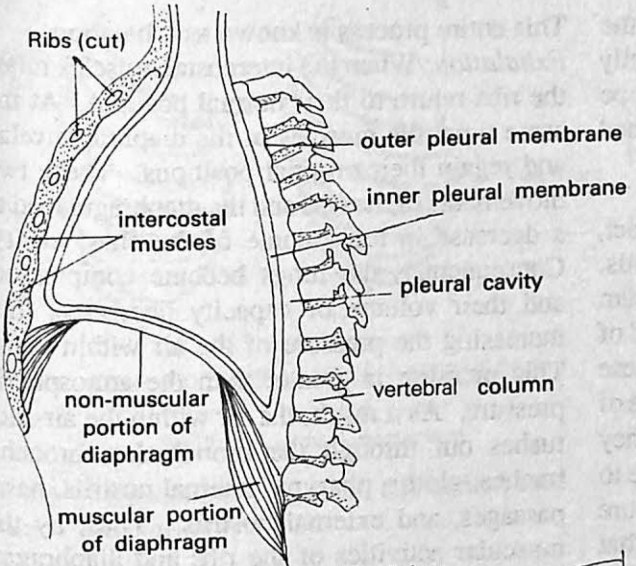


Fig. 2.20 Thorax — lateral view

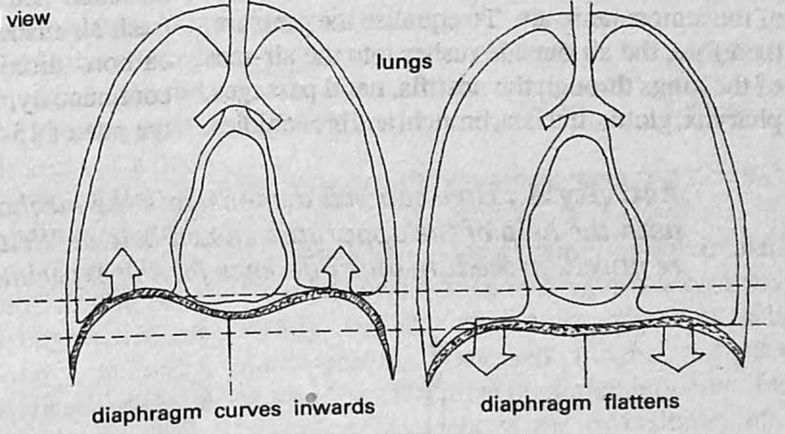


Fig. 2.21 External respiration

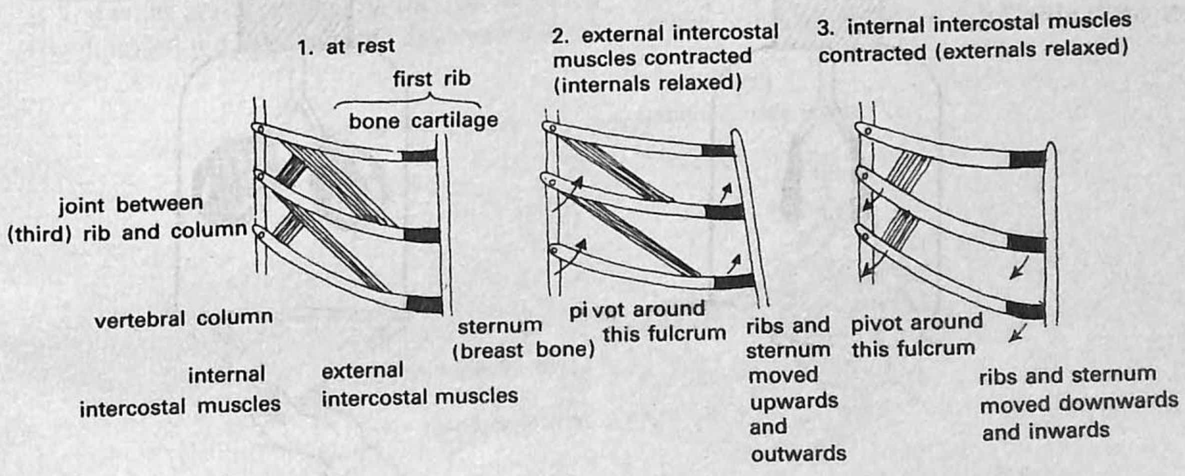

1. at rest
first rib
bone cartilage
joint between (third) rib and column
vertebral column
sternum (breast bone)
internal intercostal muscles
external intercostal muscles
2. external intercostal muscles contracted (internals relaxed)
pivot around this fulcrum
ribs and sternum moved upwards and outwards
3. internal intercostal muscles contracted (externals relaxed)
pivot around this fulcrum
ribs and sternum moved downwards and inwards

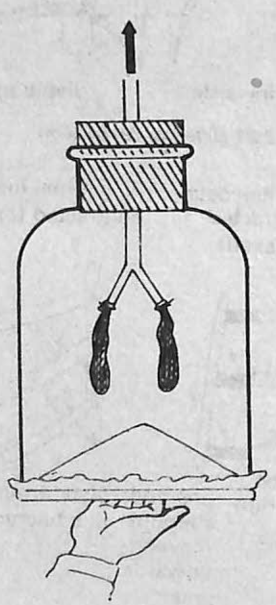
Fig. 2.22 Diagrams showing movements of rib cage

muscular movements of the diaphragm and the *intercostal muscles* which are arranged diagonally between the ribs. When released, the ribs slope downward and upwards. The diaphragm is arched or dome-shaped.

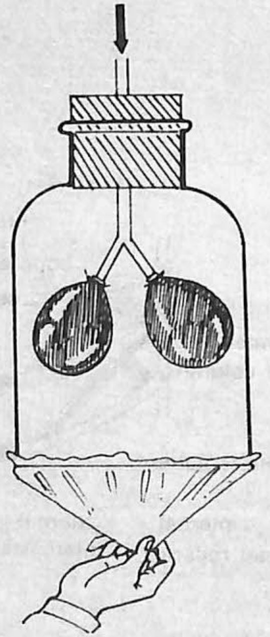
Inhalation: When the intercostal muscles contract, the ribs are made to swing upwards and outwards. Since the position of backbone is fixed the sternum moves forward. Simultaneously, the muscles of the diaphragm contract, flattening it. Both these movements result in an increase in the volume of the chest cavity. Since the lungs are elastic, they expand to occupy this increased volume. Due to an increase in the volume of the lungs, the pressure of air inside them is reduced and is less than that of the atmospheric air. To equalise the pressure, therefore, the air outside rushes into the air-sacs of the lungs through the nostrils, nasal passages, pharynx, glottis, trachea, bronchi and bronchioles. This entire process is known as inhalation.

Exhalation: When the intercostal muscles relax, the ribs return to their normal position. At the same time, the muscles of the diaphragm relax and regain their original positions. These two movements of the ribs and the diaphragm lead to a decrease in the volume of the chest cavity. Consequently, the lungs become compressed, and their volume or capacity decreases, thus increasing the pressure of the air within them. This pressure is greater than the atmospheric pressure. As a result, the air within the air-sacs rushes out through the bronchioles, bronchi, trachea, glottis, pharynx, internal nostrils, nasal passages, and external nostrils. Thus, by the muscular activities of the ribs and diaphragm, fresh air rushes into the lungs, while air rich in carbon dioxide rushes out of the lungs continuously, involuntarily and unconciously at the rate of 15-20 times per minute.

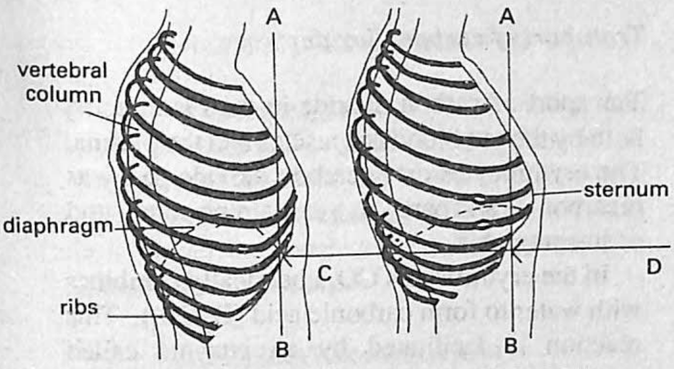
Activity14 : *How can you demonstrate the mechanism of breathing with the help of the apparatus shown below? Write the aim, apparatus required, procedure and inference for the experiment.*



Exhalation



Inhalation



, AFTER EXPIRATION AFTER INSPIRATION

Fig. 2.23 Breathing mechanism

2.8 Gaseous exchange in the alveoli and tissues:

Inspiration is followed by the process of *gaseous exchange*. The oxygen contained in the inspired air diffuses into the blood in the capillaries surrounding the alveoli. Blood present in the capillaries around alveoli or air sacs has a high concentration of carbon dioxide, but a little amount of oxygen as compared to the air present inside the lungs. The oxygen of the air diffuses into the blood and combines with haemoglobin to form *oxyhaemoglobin* which gives the bright red colour to oxygen-rich blood. Blood containing oxyhaemoglobin is known as *oxygenated blood* while that in which the oxygen has been used up is known as *deoxygenated blood.* In the latter, which is dull red in colour, the oxyhaemoglobin has been reconverted to haemoglobin. The carbon dioxide resulting from metabolic process within the cells diffuses into the blood. Most of the carbon dioxide is transported in the blood as bicarbonate ions (HCO_3). This blood is brought to the lungs where the bicarbonate ions decompose to give carbon dioxide which diffuses into the air sacs. This can happen because the concentration of carbon dioxide in the blood is higher than in the air sacs.

The oxygen, carbon dioxide and water vapour content of inhaled air is different from that of exhaled air. This is shown in the following chart.

Gas	Inhaled air	Exhaled air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Nitrogen	79%	79%
Water Vapour	Variable	Saturated

TRANSPORTATION OF RESPIRATORY GASES

The respiratory gases are carried by the circulating blood. Transportation of oxygen is accompanied mostly by the respiratory pigment, called *haemoglobin,* contained in the red blood corpuscles. The most important property of this respiratory pigment is the reversibility of its action with oxygen. The reversible nature of its action can be expressed by the following equation:

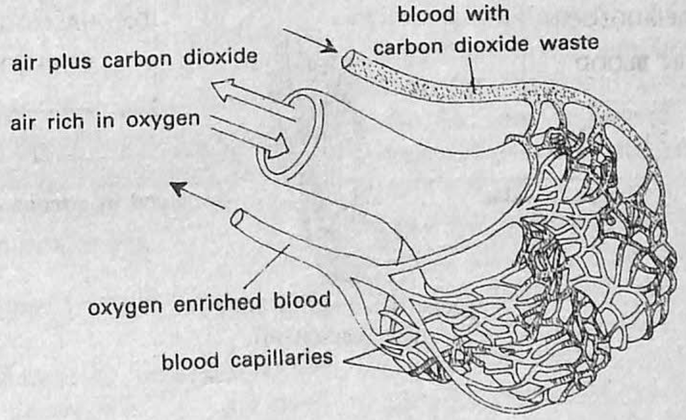


Fig. 2.24 Exchange of gases in alveoli

4

$$\text{Haemoglobin} + \text{Oxygen} \underset{\text{Tissues (less oxygen)}}{\overset{\text{Lungs (more oxygen)}}{\rightleftarrows}} \text{Oxyhaemoglobin}$$

Transport of oxygen

Oxygen diffuses from the lung alveoli into the blood plasma and then into the erythrocytes. In the erythrocytes, O_2 combines with Hb (haemoglobin) to form oxyhaemoglobin.

$Hb + O_2 \rightarrow HbO_2$ (Oxy Hb.)

When erythrocytes, loaded with O_2, reach the tissues, they give up a part of their O_2 to the tissues. The association and dissociation of Hb and O_2 are due entirely to the partial pressure (pp.) at which O_2 exists. In the lungs, O_2 exists at a pp. of 95 mm mercury (Hg). At this pressure Hb readily gets saturated with O_2. In the tissues O_2 exists at a pressure of about 40 mm Hg. At this pressure haemoglobin gives up about 60% of O_2 combined with it. Thus haemoglobin gets loaded with oxygen at high oxygen pressures and gets unloaded in the tissues where oxygen pressure is low.

Transport of carbon dioxide

Transport of carbon dioxide in man is effected both by the red blood corpuscles and the plasma. The erythrocytes carry carbon dioxide partly as bicarbonate and partly as a carbamino compound of haemoglobin.

In the erythrocytes CO_2 chemically combines with water to form carbonic acid (H_2CO_3). This reaction is facilitated by an enzyme called *carbonic anhydrase*. H_2CO_3 is a weak acid. It ionizes to form hydrogen ions and bicarbonate ions.

$CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid)

$H_2CO_3 \leftarrow H^+ + HCO_3^-$ (bicarbonate ion)

Most of the H^+ ions so liberated combine with Hb to form HHb (haemoglobinic acid). A part of HCO_3^- ions leave the erythrocytes and enter the plasma. Apart from these, about 10-20% of CO_2 combines with Hb to form $HbCO_2$ (carbamino compound). When blood reaches the lungs, all the reactions are reversed. The CO_2 is finally expelled from the lungs during expiration.

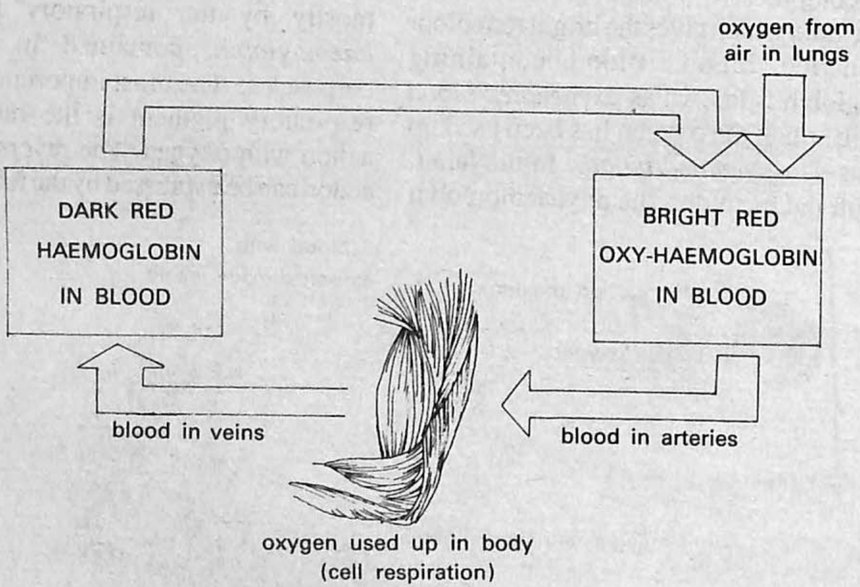


Fig. 2.25 Oxygen in our bodies

HAEMOGLOBIN AS A BUFFER

Even though a large quantity of CO_2 is transported in the blood as carbonic acid, the hydrogen ion concentration (pH) of the blood changes very little. This action of haemoglobin in maintaining the hydrogen ion concentration of blood is said to be its buffering action.

RESPIRATORY QUOTIENT

The relative proportion between the volume of carbon dioxide released and the volume of oxygen absorbed in the respiration of an animal is termed *respiratory quotient*

$$\text{R.Q.} = \frac{\text{volume of } CO_2 \text{ given out}}{\text{volume of } O_2 \text{ absorbed}}$$

Respiratory quotients have been worked out for different types of foodstuffs. For example, when carbohydrates are oxidized (100 grams of glucose) 75 litres of oxygen are absorbed and 75 litres of carbon dioxide are expelled. The respiratory quotient is therefore 75/75 = 1.

The lungs of mammals are never completely empty. In man, after each normal expiration about 3000 cm^3 of air still remains in them. Of this volume, about 1500 cm^3 can be expelled if much force is used. The remaining 1500 cm^3 can never be expelled naturally and is known as *residual air*. Each time a normal inspiration or expiration occurs, about 500 cm^3 of air moves in or out of the lungs. This is known as *tidal air*. In man the lungs are capable of holding up to 5500 cm^3 of air, and this volume is known as the *total lung capacity*. An average person breathes about fourteen to sixteen times a minute.

TISSUE OR INTERNAL RESPIRATION

The oxygenated blood from the lungs passes into the heart through the *pulmonary veins*. This blood is then distributed to all parts of the body in order that oxygen may be supplied to all the cells of the body. The exchange of gases (oxygen for carbon dioxide) between the blood and the tissues of the body is known as *internal* or *tissue respiration*. The cells in a tissue make use of the oxygen to oxidise food substances and in return give out carbon dioxide to the blood.

Oxygen from the oxyhaemoglobin of the blood does not pass directly into the cells. It first diffuses into the *lymph* or *fluid*, which bathes the cells. From here it passes by means of osmosis and diffusion into the cells. In the case of carbon dioxide, which is found in the cells, it is the lymph that absorbs this carbon dioxide before it is transferred to the blood. The lymph, therefore, acts as an intermediary, and is commonly referred to as the 'middle-man'.

Oxygen must be made available to the cells for a complete and efficient breakdown of glucose during the energy-releasing reactions.

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy (ATP and heat)

In the absence of oxygen, only a partial breakdown of glucose is possible, and this can release very little energy. Most of the energy liberated during respiration by the oxidation of glucose is stored up as ATP, while a small amount of it escapes as heat. The ATP molecule is a 'high energy packet' that supplies a suitable form of energy for biological activities. These ATP molecules are produced by the numerous mitochondria which are known as the 'power houses' of the cells. In fact, respiration is an energy intensifying process during which 'energy currency of cells' such as ATP, are produced from 'low energy packets' of a food molecule, such as glucose. The fuel foods are supplied to the cells by the digestive system, while oxygen is supplied by the respiratory system.

Respiration

External respiration
(gaseous exchange)

The respiratory tract
external nares
↓
nasal cavity
↓
pharynx
↓
larynx
↓
trachea
↓
bronchi
↓
lungs (alveoli)

Internal respiration
(cellular respiration)

Some basic concepts

1. The breaking up of complex foods into simpler forms with the help of enzymes is called *digestion.*
2. Even at rest, the cells of an organism need energy because various physiological processes continue to take place.
3. The following equation represents respiration chemically:

   $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + (energy 2830 kj)

   (glucose)
4. Two types of respiration occurs in living organism — breathing (external respiration) and tissue respiration (internal respiration).

Some suggested projects / activities

1. *Benedict's test: Take 1ml. of glucose solution and add equal column of Benedict's solution in a clean dry test tube. Heat the mixture for two minutes. A brick red precipitate is formed, indicating the presence of reducing sugars.*
2. *Fehling's test: Take 1ml. of glucose solution in a dry test tube and add equal volume of a mixture fehling's A and B solutions, and heat the reaction mixture for two minutes. A red precipitate is formed, indicating the presence of reducing sugars.*
3. *Iodine test: Take 2 ml. of starch solution in a dry test tube and add one or two drops of Lugol's iodine solution. It turns dark blue, indicating the presence of starch.*
4. *Xanthoproteic test: Take 2 ml. of egg albumen in a clean dry test tube and add 1 ml. of conc. nitric acid and heat the reaction mixture.*
   A white precipitate is formed, which on heating becomes a yellow precipitate and again turns to an organe yellow precipitate when a few drops of liquid ammonia are added. This confirms the presence of proteins.

5. *Salkovasky test: Dissolve coconut oil in chloroform and add equal amount of conc. sulphuric acid. The solution turns bluish red, indicating the presence of fat.*
6. *Survey any two slums near your house. Record cases of persons suffering from malnutrition. Prepare a medical report, giving the history of each patient. Suggest remedial measures for each disease.*
7. *Make a list of the common lung and respiratory diseases.*
   Find out the symptoms, and preventive measures of each disease. Exchange your findings with your classmates.
8. *Devise simple experiments to show that exhaled air contains more carbon dioxide and more moisture.*

REVISION

I Choose the correct answer

a. Each of the following is a function of the liver except
i) the production of bile. ii) deanimation. iii) the storage VItamin A.

b. Most of the products of fat digestion are transported from the gut by
i) the arteries and the veins. ii) diffusion from cell to cell. iii) osmosis from cell to cell. iv) the lymphatic system.

c. The substances that convert insoluble foodstuff into a soluble state are called
i) enzymes. ii) hormones. iii) juices. iv) vitamins.

d. The function of enzyme ptyalin is
i) convert proteins into peptones. ii) convert peptones into amino-acids.
iii) convert starch into sugar. iv) convert fat into fatty acids.

e. Before release into the alimentary canal, bile is stored in the
i) bile duct. ii) liver. iii) duodenum. iv) gall bladder.

f. Bile is secreted by the
i) liver. ii) pancreas. iii) kidney. iv) wall of the stomach.

g. The name of the enzyme produced by the salivary glands is
i) pepsin. ii) renin. iii) ptyalin. iv) bile.

II Differentiate between

a. ingestion and egestion
b. absorption and assimilation
c. anabolism and catabolism
d. salivary amylase and pancreatic amylase.

III Answer the following questions

a. Briefly describe the digestive system of man.

b. Name the three types of digestive enzymes and state their functions.

c. Briefly describe the digestion in the mouth and stomach, indicating the chemical changes undergone by various classes of food during the process of digestion.

d. Explain the process of absorption of digested food.

e. What is the fate of the following materials after they have been digested?
a. protein. b. fats. c. carbohydrates.

f. If the stomach of a person has to be removed on medical grounds, what special diet would you recommend for him and why?

IV Choose the correct answer:

1. The alveoli are the sub-division of the
a. infundibulum. b. alveolar duct. c. bronchioes d. none of the above.

2. In the pregnant condition, a woman respires easily with the help of her
a. diaphragm. b. costal muscles. c. radial muscles. d. all of the above.

3. The respiratory centre is found is the
a. medulla oblongata. b. cerebellum. c. diencephalon. d. cerebrum.

4. The air that enters during inspiration and is given out during expiration is
a. residual air. b. residual volume. c. vital capacity. d. tidal volume.

5. All the following are lung disease except
a. encephalitis. b. bronchitis. c. asthma. d. pneumonia.

6. Lungs dilate or normalize not by expansion or contraction of their own walls but that of the diaphragm and chest because their walls are
a. non-contracitle. b. thin. c. thick. d. elastic.

7. Intercostal muscles bring about the contraction and expansion of the
a. diaphragm. b. ribs. c. abdomen. d. chest.

8. Which of the following is not an air conducting passage?
a. bronchiole. b. trachea. c. larynx. d. oesophagus.

9. The infection of pleura causes a deadly disease known as
a. bronchitis. b. meningitis. c. pleurisy. d. arthritis.

V Fill in the blanks

1. The opening of the larynx is guarded by a flap-shaped structure called ____________
2. The larynx is also known as ____________
3. The alveolar ducts open into blind chambers known as ____________
4. Each lung is surrounded by a double-walled membranous sac called ____________
5. Blood containing oxyhaemoglobin is known as ____________
6. The thorax is separated from the abdomen by a dome-shaped muscular wall known as ____________
7. ____________ are the power house of the cells.
8. The ____________ is a muscular chamber where the digestive and respiratory tracts cross each other.

VI Define

a. respiration. b. inspiration. c. expiration. d. mechanism of respiration. e. breathing. f. tissue respiration.

VII Answer the following:

1. Compare inhaled and exhaled air.
2. How does breathing differ from respiration?
3. Explain the mechanism of breathing.
4. Compare and contrast the oesophagus and the trachea, the tubes arising from the floor of the pharynx.
5. What is epiglottis? What is its function?
6. Describe the structure of the lungs. Explain how they are adapted for an efficient exchange of respiratory gases.
7. Explain the mechanism of tissue respiration.

VIII State whether the following true or false.

1. ATP contains energy rich bonds
2. Alveoli are found in fishes.
3. The adult frog breathes through gills.

3. Cellular organisation

Functional organisation of a generalised cell-differences between cells - cell theory - light microscopic structure of plant and animal cells (eukaryotic) - the organelles - position and relationship - structure of cell under electron microscope - difference between plant and animal cell - (cell wall, vacuole, centrosome, plastids) - chromosome number and importance - chromosome number in man and fruit fly - autosome and sex chromosomes - cell division - mitosis and its significance.

The bodies of all living organisms are made up of cells. These are tiny microscopical units which collectively carry out the processes that make the organism a living entity. Even the simplest organisms are composed of cellular materials, i.e., molecules found inside the cells of more complex organisms. The cell, then, seems to be the basic structural and functional unit of an organism, and so it is not surprising that biologists have devoted a great deal of attention to its structure and the activities which go on inside it.

THE DISCOVERY OF CELLS

Cells are too small to be seen with the naked eye and can only be observed under a microscope. The first simple microscope was invented in 1590 by a spectacle maker of Holland named Zacharias Jansen. Later, Galileo (1610) also built a microscope to study minute living organisms. Robert Hooke (1665) built a compound microscope and employed it to study thin slices of cork and other structures in detail.

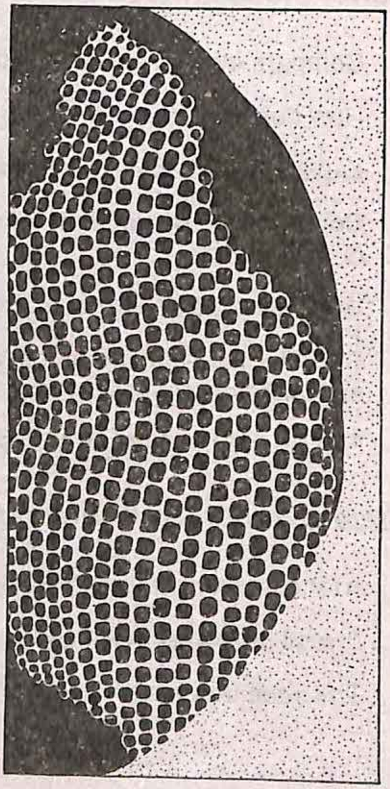


Fig. 3.1 Cells from a thin slice of cork as seen by Hooke (1665)

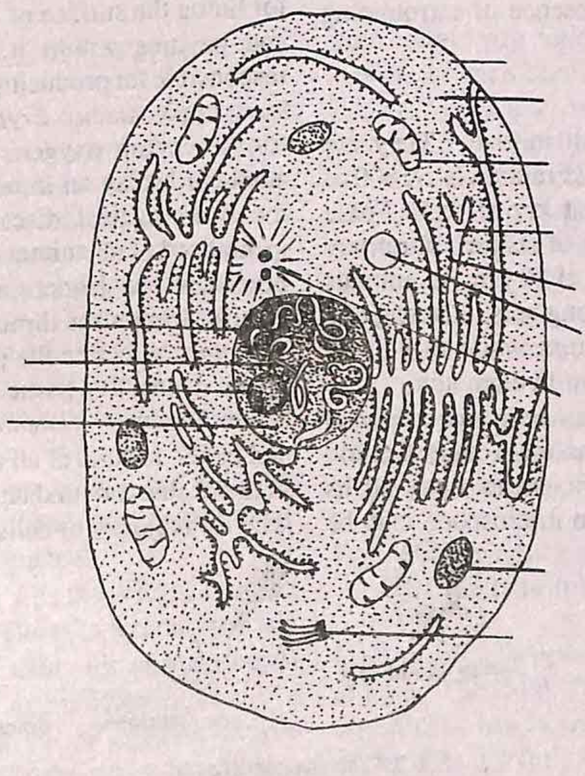
He noticed many small compartments in the slices of the cork and gave these the name *cells*. Leeuwenhoek (1672-76) studied some unicellular organisms and Lamarck (1809) concluded that every living body was made up of a mass of cellular tissues in which liquid substances moved about. Dutrochet (1824) concluded that the growth of an organism is caused by the increase in the number and size of its cells. Subsequently Robert Brown in 1833-35 discovered the presence of a nucleus in each cell and Dujardin (1835) clearly noted the presence of a semi-fluid substance inside the cells. The semi-fluid substance within the cell was named *protoplasm* by Purkinje (1839-40). In 1868 T.H. Huxley described protoplasm as the *physical basis of life*.

3.1 Functional organisation of a generalised cell

It may be pointed out that a generalised cell does not exist in reality. It is constructed by the biologist, combining the common features of cells that make up the bodies of plants and animals.

A cell is a microscopic unit mass of protoplasm surrounded by a selectively permeable membrane. In plants the cells are additionally surrounded by a cell wall.

Activity 1: *Work in groups and examine the illustration given below. It shows the structure of a generalised cell. Try to recall what you studied about this in class 6 (or do some reference in your school library) and label all the parts marked.*



A generalised cell.

THE DIVERSITY OF CELLS-CELLS ARE NOT THE SAME

Cells in plants and animals vary in their size, shape and organisation.

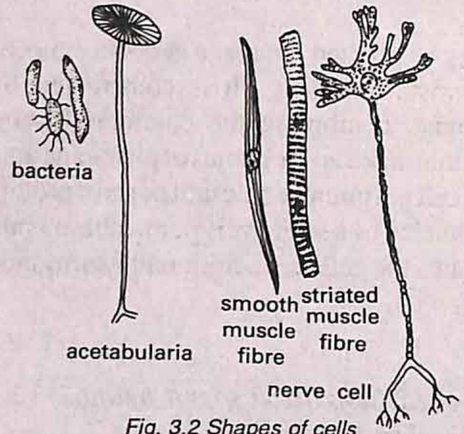


Fig. 3.2 Shapes of cells

Cell shape

A cell can be spherical, oval, rectangular, polygonal or irregular in outline. The shape of the individual cell depends upon its hereditary characteristics and the presence of surrounding cells.

Cell size

Cells are often very small in size. They are measured in microns (μ). (1 micron is 1/1000 of a mm.) This is the largest known cell. Some bacterial cells have a size of 0.2μm. Ordinary cells have an average size of 10 μm. In animals the nerve cells have very long tails. The egg of a hen measures 6–7 cm across while that of an ostrich may be about 17 cm in diameter.

Cells are so minute that an ordinary compound microscope which has a maximum magnification of 2000, may not be sufficient to study all its parts. Instead, an electron microscope may be used which has a magnification of up to 2,00,000. This microscope does not contain a lens, but, instead, beams of electrons are passed through the material to be magnified. Magnetic fields are then set up which enlarge the object.

Life span of cells

The cells of several unicellular organisms are virtually immortal because their usual mode of reproduction is by binary fission. The cells of multicellular organisms differ in their life span. Some die very soon while others are replaced very slowly. For example, some white blood cells are replaced after every 1–3 weeks while red blood cells have a life span of about 120 days.

Types of cells

In the human body there are different types of cells, each is highly specialised and adapted for a particular function. Thus *epithelial cells* possess a shape and form that makes them most suitable for lining the surface of the body and the organs and cavities within it. *Glandular cells* are responsible for producing some kind of secretion, for example, *mucus*. *Erythrocytes* are responsible for conveying oxygen. *Leucocytes*, generally amoeboid, play an important part in defending the body against disease. One of the most specialised of all animal cells is the *nervel cell* or neuron, whose slender arm-like processes transmit electrical impulses through the nervous system. *Fibroblasts* secrete the protein fibres that make up the connective tissue which binds tissues and organs together. *Osteoblasts* produce cartilage and bone. In spite of all these variations, there is a remarkable and fundamental similarity between the vast majority of cells.

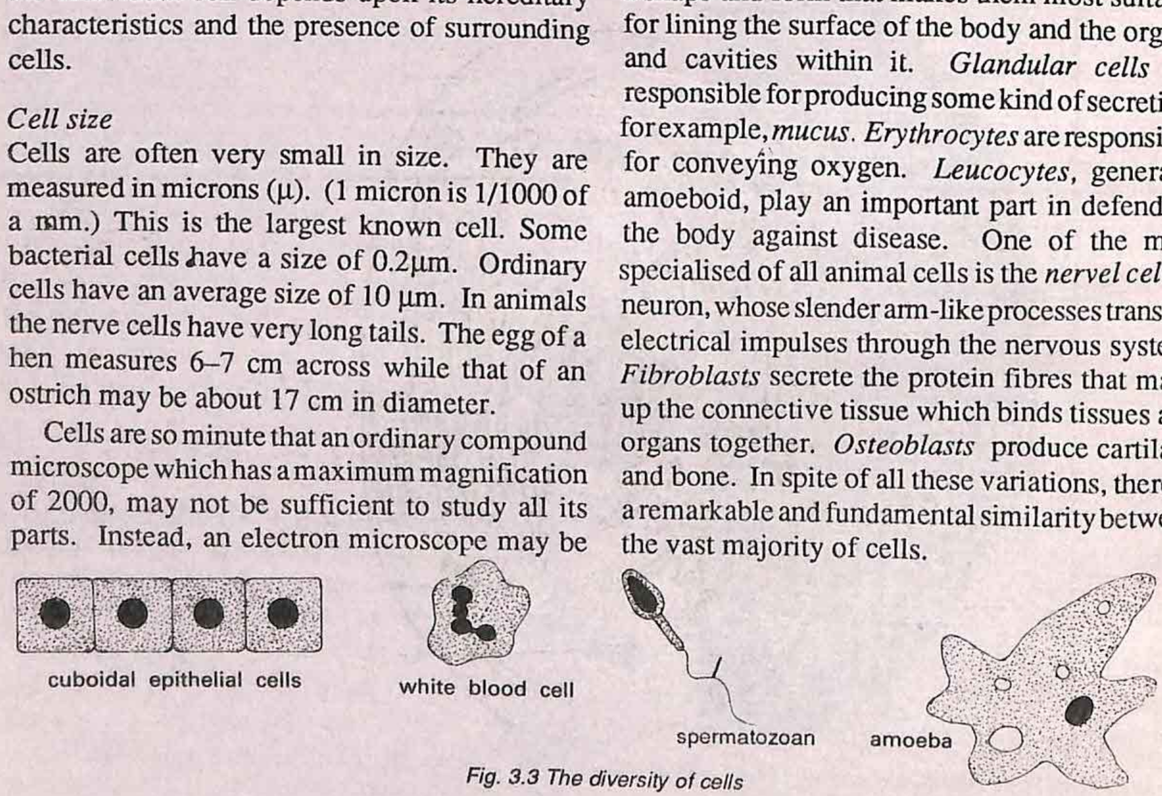


Fig. 3.3 The diversity of cells

3.2 Cell theory

Rudolph Virchow(1865) discovered that cells divide and put forward the idea that new cells are formed only by the division of pre-existing cells. Meanwhile, the Belgian botanist Schleiden and the German zoologist Schwann recognised the similarity between the structures of plant and animal cells published in their paper *Microscopic investigations on the similarity of structure and growth in animals and plants* (1838). They also put forward the famous *Cell theory*, according to which the activity of an organism is the sum total of the activities of its cells.

From the above we can make three fundamental assumptions about cells. They are: 1. cells are the structural units of all organisms; 2. cells are the units of function in organisms; and 3. cells arise from the division of the pre-existing cells. The word cell (L.*cella*– compartment) as understood today is a small mass of protoplasm with a definite organisation, surrounded by a plasma membrane and containing a nucleus and other structures.

The cell theory is one of the most important scientific conclusions of that time. It is said to be one of the foundation stones of Modern Biology.

Activity 2: *Peel off a small piece from the surface of a leaf of maize. Spread it on a glass slide. Cover it with a drop of water or iodine solution. Examine the shape, size and various parts of the cells.*

Activity 3: *Run an ice cream spoon inside your cheek. Smear the fluid collected on a glass slide. Stain it with methylene blue. Identify the structure of the cells.*

3.3 Light microscopic structure of plant and animal cells

Cells are usually first examined under a light microscope (a compound microscope in which ordinary light is used as the source of illumination is called a light microscope). Therefore, let us first study a typical cell under a light microscope.

STRUCTURE OF A CELL.

Cells of living organisms are classified into the following two types 1. *Eukaryotic cells, i.e.*, cells of fungi and higher plants and animals. These contain organelles bounded by membranes and also contain a true nucleus.

2. *Prokaryotic cells, i.e.*, the cells of bacteria and blue green algae, These lack a nucleus and contain only a few (and sometimes none) organelles bounded by membranes.

A cell is bounded by a delicate elastic membrane called the *cell membrane*. In addition, plant cells have a *rigid wall* made up of cellulose outside the membrane. The cell is filled with a viscous, jelly-like substance, the *cytoplasm*. Embedded in the cytoplasm is a dense body called the nucleus containing *nucleoplasm* and *nucleoli*. The cytoplasm also contains a large number of organelles, some of which, like the chloroplasts of plants, are visible under the light microscope. Plant cells also contain large vacuoles, bounded by a membrane. The vacuole contains *cell sap* which is an aqueous solution of organic compounds, minerals and waste matter. Animal cells have very small vacuoles or they may be absent altogether.

3.4 The structure of cell as revealed under the electron microscope

Electron microscopes use electrons as the source of light. The study of the cell under the electron microscope has revealed several finer details of of the cells not fully understood earlier.

The fine or *ultrastructure* of the cells shows the following features:

I. THE NUCLEUS

The nucleus is a specialised protoplasmic body which is denser than cytoplasm. It is rounded or oval in outline, and is differentiated into four parts–*nuclear membrane*, *nucleoplasm*, *chromatin reticulum* and one or more *nucleoli*.

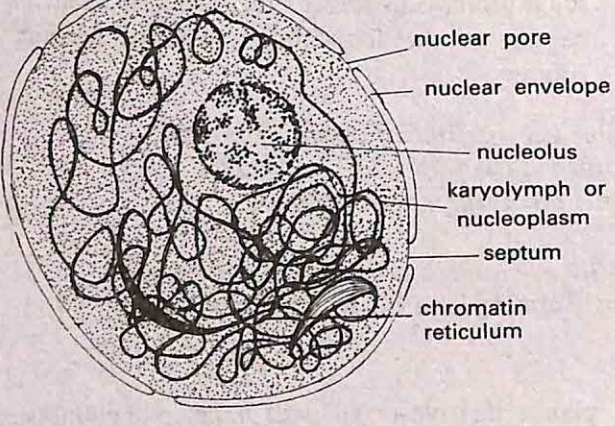


Fig. 3.4 The structure of a nucleus

The *nuclear membrane* is the outer delicate covering of the nucleus. It is actually double layered and contains pores of different dimensions.

The *nucleoplasm* is the protoplasmic substance of the nucleus. It is also known as *nuclear sap* or *karyolymph*. Embedded in the nucleoplasm are a number of highly elongated *chromosomes* which are often known as *chromatin threads*. The chromatin threads overlap one another so as to give the appearance of a network called *chromatin reticulum*. At the time of cell division the chromosomes become clearly visible.

THE CYTOPLASM

This is the executive region of the cell where most of the metabolic activities take place. The peripheral layer of the cytoplasm is viscous, clear and rigid and is known as the *ectoplasm*. The inner portion of cytoplasm is granular, less viscous and known as the *endoplasm*. The cytoplasm is surrounded on the outside by a membrane called *plasma membrane* or *plasmalemma* (Gk. *plasma* – form, *lemma* – skin.)

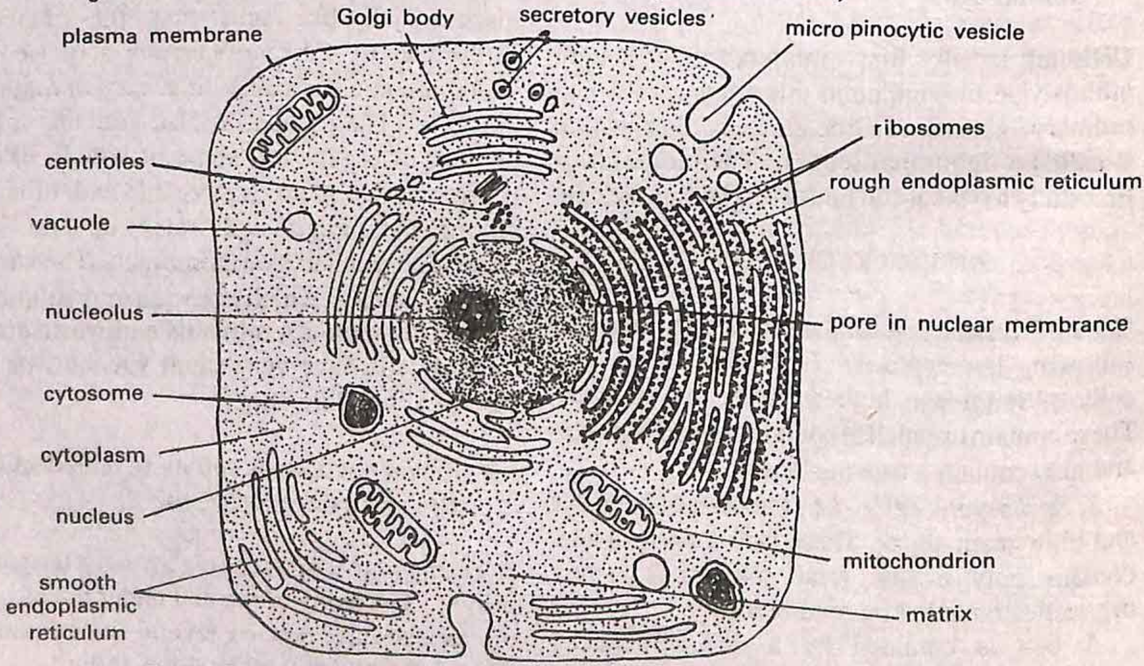


Fig. 3.5 The structure of an animal cell based on studies with the electron microscope

Plasma membrane

The plasma membrane is the living, ultra-thin, elastic, porous and semi-permeable membranous covering of the cell. Any injured part of it is repaired within no time. It is *selectively permeable* and controls the entry and exit of small ions and molecules to and from the cytoplasm. The plasma membrane participates actively in the ingestion of certain large-sized foreign particles or food substances. The process by which the foreign substances are taken in and digested is known as *endocytosis*. According to the nature of the food or foreign substances endocytosis may be classified under two types viz.,

1 *pinacocytosis*, and

2. *phagocytosis*.

The process of ingestion of fluid material in bulk by the cell through the plasma membrane, is known as *pinacocytosis*. The process of ingestion of large-sized solid substances by the cell through the plasma membrane is known as *phagocytosis*.

CYTOPLASMIC INCLUSIONS

The various structures present in the cytoplasm are called *cytoplasmic inclusions*. They are both protoplasmic (living) and deutoplasmic or paraplasmic (non-living). The cytoplasmic inclusions include oil drops, yolk granules, secretory granules and glycogen granules. Besides the cellular inclusions, the cytoplasm also contains many large-sized structures known as *cell organelles* or *organoids* which perform various vital metabolic activities such as respiration, storage, synthesis, transportation, support and reproduction. The cell organelles are the endoplasmic reticulum, ribosomes, Golgi complex, lysosomes, mitochondria, plastids (only found in plant cells) centrioles, etc.

1. *Endoplasmic reticulum:* The cytoplasm is traversed by a large reticulum or network of inter-connecting tubules known as *endoplasmic reticulum*. The endoplasmic reticulum has a vast and interconnected cavity which remains bounded by a single membrane.

   The membranes of the endoplasmic reticulum may be either smooth, when they do not have ribosomes, or rough when they have ribosomes attached to them. The membranes of the endoplasmic reticulum are found to be continuous with the nuclear membrane and plasma membrane.

   The function of the endoplasmic reticulum is the transportation of substances from the exterior to the nucleus or to the cytoplasmic organelles. It also provides mechanical support to the cytoplasm.

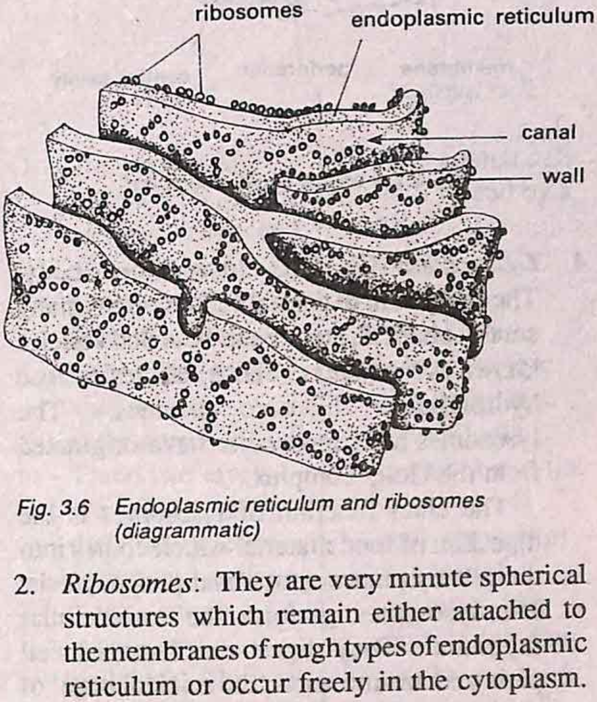


Fig. 3.6 Endoplasmic reticulum and ribosomes (diagrammatic)

2. *Ribosomes:* They are very minute spherical structures which remain either attached to the membranes of rough types of endoplasmic reticulum or occur freely in the cytoplasm. Ribosomes can form groups or aggregates known as *polysomes* which perform the same function together. Ribsosomes are made up of RNA (called ribosomal RNA or rRNA) and proteins. Ribosomes are the centres of protein synthesis.
3. *Golgi complex (Golgi bodies or lipochondria):* The Golgi complex is a disc-shaped organelle consisting of stacks of flattened sacs (*cisternae*), small vesicles and vacuoles of various sizes. The membranes of

the Golgi complex are made up of lipoproteins. Golgi bodies mainly help in the storage of proteins, lipids and carbohydrates. It also probably helps in the formation of hormones, cell wall material and certain cell secretions.

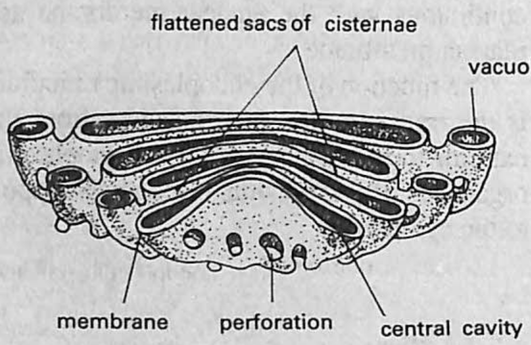


Fig. 3.7 A portion of Golgi complex

4. *Lysosomes:* Gk. *lysis*– loose, *soma*- body. The cytoplasm of animal cells contains many small, spherical, membrane-bounded vesicles known as *lysosomes*. These vesicles enclose hydrolytic or digestive enzymes. The lysosomes are supposed to have originated from the Golgi complex.

   The chief function of lysosomes is the digestion of food material which comes into the cell by pinacocytosis and phagocytosis. The lysosomes perform the extracellular digestion. They digest the damaged cell parts and are known as 'the suicidal bags' of the cell. During starvation lysosomes digest the stored food contents of the cytoplasm.

5. *Mitochondria* or *chondriosomes:* (Gk. *mitos* – thread, *chondrion* -grain). In the cytoplasm of most cells large-sized filamentous, rounded or rod-like structures known as mitochondria may be seen. The mitochondria occur singly or in groups scattered throughout the cytoplasm.

   The mitochondria are bounded by two membranes of lipoproteins. The outer membrane forms a bag-like structure around the inner membrane, which gives out many finger-like folds in the lumen of the mitochondria. The folds of inner mitochondrial membrane are known as *cristae* or *mitochondrial crests*. The cristae bear innumerable dumb-bell shaped outgrowths known as *electron particles*. The space between the outer and the inner membranes as well as the central space is filled up by a viscous mitochondrial matrix.

   Mitochondria are considered to be the 'power houses' of the cell because they are the seat of aerobic respiration and oxidative phosphorylation. They also synthesise the energy-rich compound ATP (Adenosine triphosphate). The energy stored in this process is used later for various activities of the cell. They are the actual respiratory organs of the cells where the foodstuffs are completely oxidised into CO_2 and H_2O.

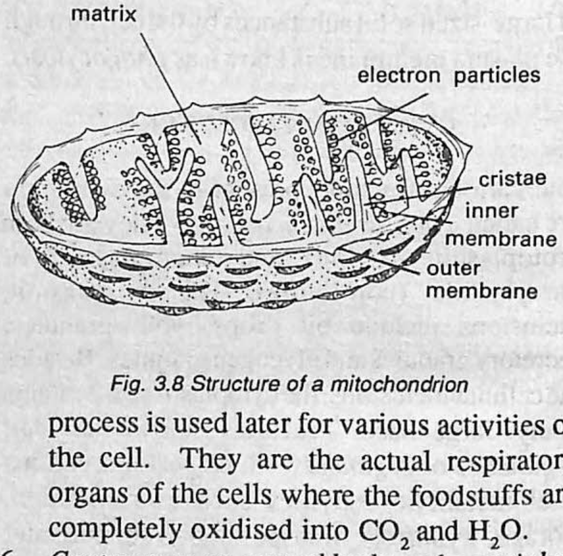


Fig. 3.8 Structure of a mitochondrion

6. *Centrosome* or *central body* and *centrioles*: The centrosome contains dense cytoplasm and is located near the nucleus of animal cells. During cell division the centrosome is found to contain two rod-shaped granules known as *centrioles*. The centrioles are covered over by a sheath of cytoplasm called *centrosphere*.

   At the time of cell division the centrioles produce the spindle fibres and astral bodies and they decide the plane of cell division.

7. *Microtubules* : Electron microscopy has recently revealed the occurrence of very fine tubules in the cytoplasm of plant and animal cells. These tubules are known as *microtubules*.

   The function of the microtubules is the transportation of water, ions or small molecules and the formation of fibres or asters of the spindle during cell division.

8. *Cytoplasmic vacuoles* (L. *vacuus* - empty.): They are fluid-filled spaces present in the cytoplasm. An animal cell contains only a few small vacuoles. In plant cells vacuoles are more abundant and all of them fuse to form a large *central vacuole* in the mature plant cell.

   Each vacuole is surrounded by a membrane called *tonoplast* and is filled with *cell sap*. The cell sap is a mixture of many inorganic and organic substances. Plant vacuoles often contain water-soluble pigments called *anthocyanins*. The colour of many flowers is due to their presence.

9. *Plastids* : They are present in the cells of green plants and a few primitive organisms which can be included both among plants and animals, e.g., *Euglena*. Plastids are of three kinds:

   a. Chloroplasts : (Gk. *chloros* – grass green, *plastos* – formed.) They are green plastids. *Chlorophyll* is the most important pigment contained in them. It is essential for the manufacture of carbohydrates during photosynthesis. They are only found in the parts of plants exposed to light.

   b. Chromoplasts : (Gk. *chroma* – colour, *plastos* – formed). They are coloured plastids which do not possess cholorophyll. These impart attractive colours to the cells. The pigments present are *xanthophyll* (yellow) and *carotene* (orange and red).

   c. Leucoplasts : (Gk. *leukos* – white, *plastos* – formed.) They are colourless plastids. They generally take part in storing starch and are, therefore, known as *amyloplasts*. (Gk. *amylon* –starch, *plastos* – formed.) They are found in the cells of underground stems and roots.

3.5 Difference between plant cell and animal cell

Comparison between plant and animal cells
(as seen under the light microscope)

Plant cell	*Animal cell*
1. The plant cell is bounded by a thick *cell wall* composed of non-living material and divided into two layers, the *primary wall* and the *secondary wall*. These two layers are made up of different types of substances such as *lignin, pectin, tannin* and *cellulose*. The most important of all these substances is the cellulose which is found in all plant cells. The cell wall is generally thick and does not change its shape.	1. The animal cell is bounded by a thin *cell membrane* or plasma membrane which encloses the cytoplasm. The plasma membrane is not made up of cellulose but of lipids and proteins. The animal cell does not have a thick, rigid cell wall. Owing to the delicate and flexible nature of the cell membrane the shape of an animal cell can change.
2. The vacuoles of	2. The vacuoles of

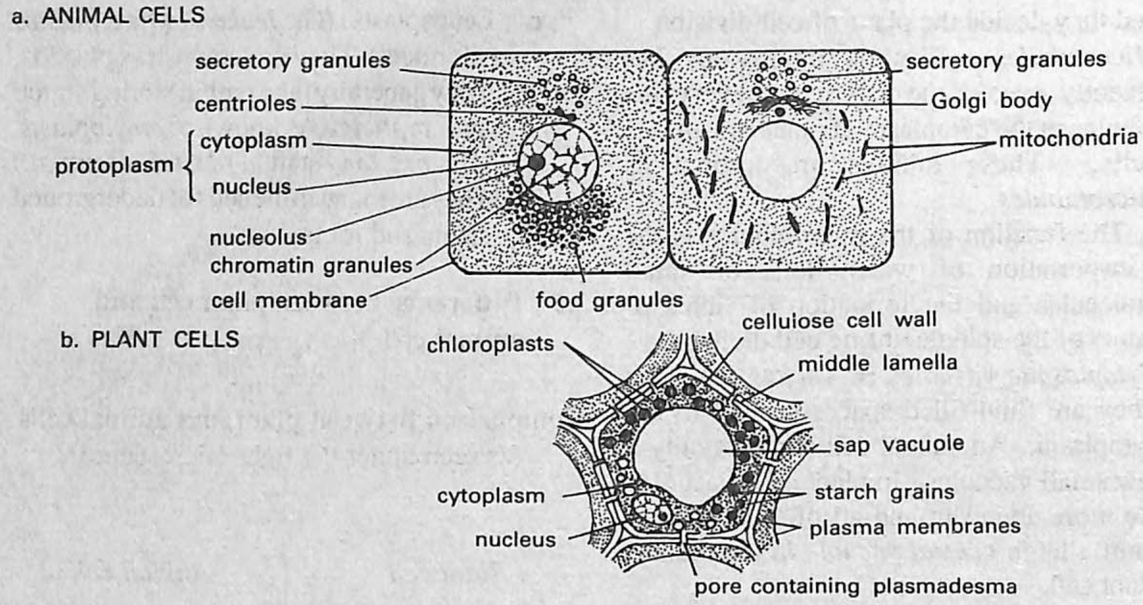


Fig. 3.9 The structure of plant and animal cells as seen under the light microscope

plant cells are bounded by a single, semi-permeable membrane, the tonoplast. These vacuoles contain water, anthocyanins (blue and red pigments), alkaloids and storage products such as sugars and proteins. There are many vacuoles in a young plant cell but all of them fuse to form a large *central vacuole* in the mature plant cell.	animal cells are bounded by lipoproteinous membranes and their functions is the storage and transmission of materials and the maintenance of internal pressure of the cell. An animal cell contains only a few small vacuoles.
3. *Plastids* are present in the cytoplasm of plant cells. The green plastids, *chloroplasts* contain *chlorophyll* and gives the green colour to leaves and stems. Chloroplasts are essential for the manufacture of carbohydrates. Leaves which are red and yellow in colour contain coloured plastids known as *chromoplasts*. These contain the red and yellow pigments *carotene* and *xanthophyll*. *Leucoplasts* are colourless plastids and take part in storing starch. The plastids perform various	3. Plastids are absent in the case of animal cells. Oil droplets, yolk granules, pigments, secretory granules are present in the cytoplasm of an animal cell.

synthetic and metabolic activities.	
4. The centrosome with centriole is absent.	4. The centrosome is located near the nucleus of animal cells. The two centrioles lie at right angles to each other. The centrosome is concerned with cell division.
5. There are no lysosomes.	5. Lysosomes are present.

3.6 Chromosome number and importance.

Chromosomes are small thread-like bodies which are present in the nucleus of a cell. Normally the chromosomes are too thin to be noticed but during cell-division they become thick and become easily visible under an electron microscope. The main function of the chromosome is to bear the hereditary units called *genes*. Genes control the different characteristics of an organism, like its height, colour, etc.

Chromosomes are condensed chromatin material. They are definite in number in each cell of a particular species, e.g., 46 in man, 78 in dog and so on. Chromosomes may be differentiated into *autosomes* and *allosomes*. All chromosomes other than the sex chromosomes are known as *autosomes*. Sex chromosomes are called *allosomes* which are referred to as X and Y chromosomes in human beings. In higher animals and all bisexual organisms chromosomes occur in pairs. Human beings have 23 pairs of chromosomes. Out of them 22 pairs *are normal* while the last pair determines the sex. The female has two X chromosomes while the male has XY chromosomes in this pair.

The sperms of a male are of two types. One has 22+X chromosomes and the other has 22+Y chromosomes. The eggs of a female will always have 22+X. When a 22+Y chromosomes sperm is successful in fertilising the egg, a boy will be conceived. If 22+X sperm takes part in fertilisation, a girl will be conceived. Thus there is equal chance for the two types of children to be born.

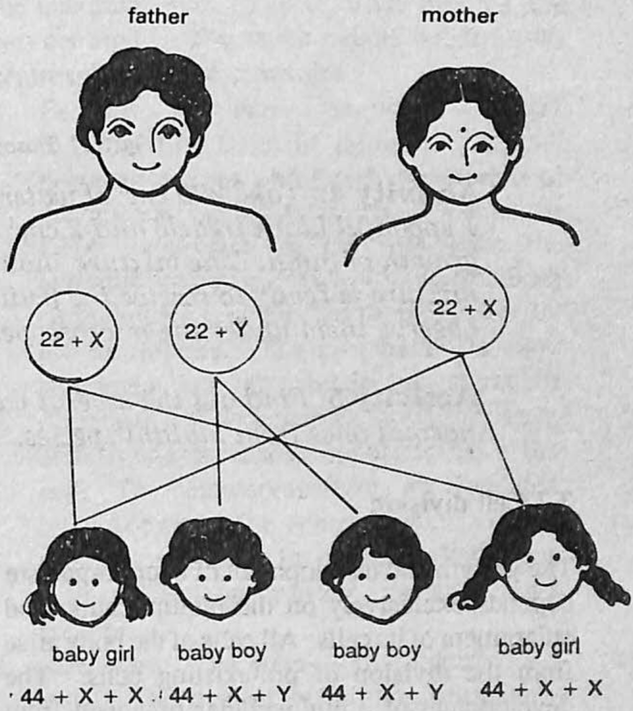


Fig. 3.10 The birth of a boy or girl is purely a chance

In India wheat is the second major cereal crop next only to rice. The most commonly cultivated wheat species in India is, the hexaploid wheat, Triticum aestivem.

The chromosome number of wheat is 42. The *chromosome number of* potato is 48, cherry trees 32, garden peas 14 and so on.

The fruit fly (Drosophila melanogaster) has four pairs of chromosomes. The cells of this insect have been widely used in experiments in genetics.

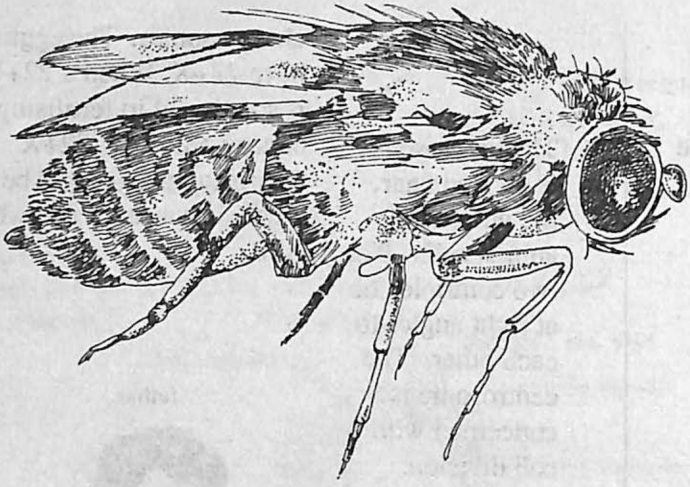


Fig. 3.11 Drosophila melanogaster.

Activity 4: *Take 200 cm³ of water, 30 gm of quaker oats, 3gm of agar, 1 spoonful black treacle and 2 cm³ of antimould solution to prevent the growth of fungi. The mixture should be cooked and then cooled. The mixture is ready to receive the fruit flies. Catch some fruit flies and observe them under the microscope.*

Activity 5: *Find out the several varieties of Drosophila. Separate the normal ones from mutant species.*

3.7 Cell division

The growth and development of every organism depends exclusively on the multiplication and enlargment of its cells. All cells of the body arise from the division of pre-existing cells. The development of a multicellular organism from the unicellular zygote is achieved by *cell division, growth* and *differentiation.*

Cell division occurs in two stages, namely the nuclear division,—*karyokinesis* and the division of the cytoplasm—*cytokinesis.* Usually, karyokinesis is followed by cytokinesis but sometimes this does not happen and this results in the formation of multinucleate cells.

In animals and plants the following three types of cell division have been distinguished.

1. Direct cell division or amitosis.
2. Reduction division or meiosis.
3. Indirect cell division or mitosis.

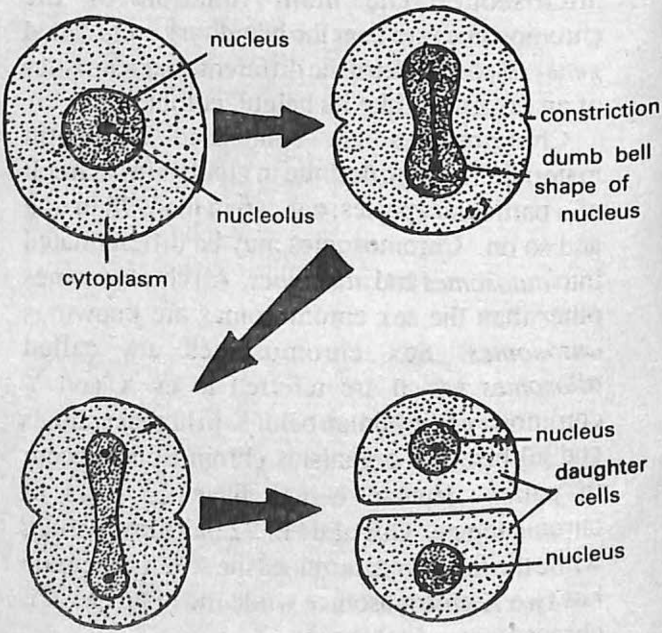


Fig. 3.12 Diagrammatic representation of amitosis

Amitosis (Gk. *amitos* — without thread)
Amitosis is also known as direct nuclear division. During amitosis the nucleus elongates first and assumes a dumb-bell-shaped appearance. The nucleus constricts in the middle and gets divided into two daughter nuclei. The latter may be equal or unequal in size. The division of the nucleus is followed by the constriction of cytoplasm which divides the cell into two equal or approximately similar halves.

Meiosis (Gk. *meioum* – to reduce)
The term *meiosis* was coined by J.B Farmer. Meiotic division is of utmost important for those organisms in which the union of the haploid gametes (having half the number of chromosomes characteristic of a somatic cell) takes place during sexual reproduction. By reducing the number of chromosomes of the diploid germ cells (having homologous pairs of chromosomes) into the haploid gametes, meiosis maintains a constant number of chromosomes in the species. In the process of meiosis, the chromosomes divide once and the nucleus and cytoplasm divide twice. In meiosis, four haploid cells are formed from a single diploid cell.

3.8 Mitosis (Gk. mitos—thread)

Mitosis is also known as *indirect nuclear division.* It occurs in the somatic cells of plants and animals. In mitosis the resultant daughter cells have the same size and the chromosome number remains the same as the parent cell.

The nucleus is composed of the *chromatic apparàtus* which includes the chromosomes and the nucleolus and the *achromatic apparatus* which in its turn includes the centrioles and the spindle. Mitosis is a continuous process but it has been divided into four stages for the sake of convenience. These stages are the *prophase*, *metaphase*, *anaphase* and *telophase*. The state of the nucleus before the beginning of division is called the *interphase*.

Interphase: The phase between the two mitotic divisions is known as the *intermitotic phase* or *interphase*. In interphase no division occurs but in the nucleus and cytoplasm active metabolic activities occur and also an increase in the volume of the cytoplasmic and nuclear substances takes place. During the interphase the nuclear envelop remains intact. The chromosomes occur in the form of diffused, long, coiled and indistinctly visible chromatin threads. The nucleolus attains the maximum size. The centriole divides into two centrioles. The asters radiate out from the centrosphere of the centrioles.

1. *Prophase:* (Gk. *pro*—first, *phasis* —stage) It is the first stage of mitosis. The cell becomes viscous and the disintegration of the nuclear membrane starts. Due to the DNA duplication in the interphase the chromosomes possess two *chromatids*. Both chromatids are connected to each other by the centromere. The chromatids become shortened and the nucleolus starts to disappear. The centrioles slowly separate and migrate towards the opposite poles of the cell. The centrosome forms an elongated body known as the *centrodesmus* between the two centrioles. From the centrodesmus delicate filaments or asters arise and form a spindle.
2. *Metaphase:* (Gk. *meta* — after, *phasis* — stage). The nuclear membrane completely disappears and a clear zone known as the equator appears in between the mid-line of the spindle and the nucleus. The chromosomes move towards the equator and arrange themselves radially at the periphery of the spindle. The smaller chromosomes usually remain in the interior while the larger chromosomes remain at the periphery. Some of the fibres of the spindle get attached to the centromere of each chromosome and are known as the *chromosomal fibres*. Certain fibres now appear between the chromosomes and are known as *interchromosomal fibres*.

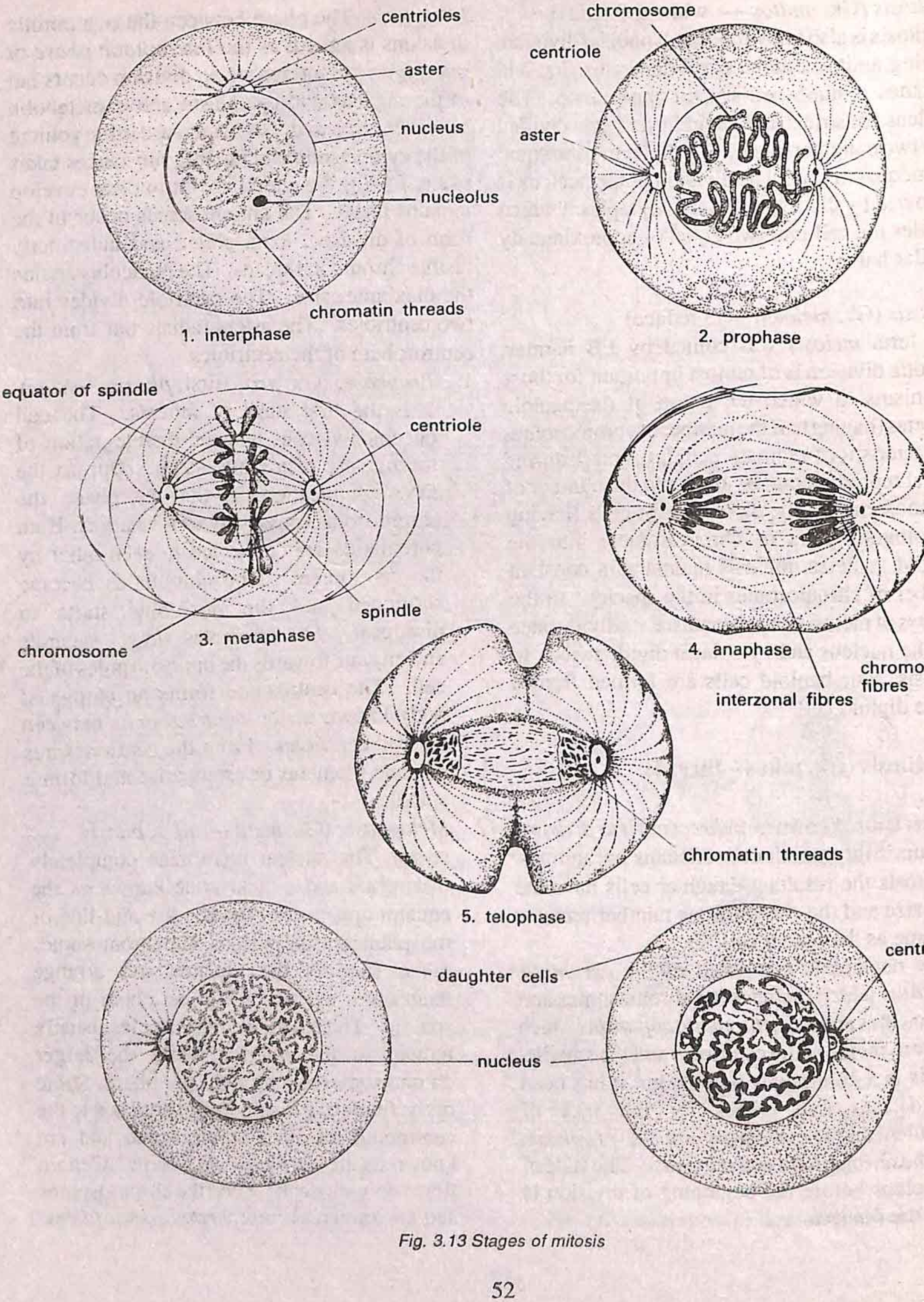


Fig. 3.13 Stages of mitosis

3. *Anaphase* (Gk. *ana* — up, *phasis* — stage): The centromere of each chromosome divides in two. The two chromatids of a chromosome separate into daughter chromosomes. The chromosomes become shorter and thicker and migrate towards the opposite poles of the cell. The migration of the daughter chromosomes towards the opposite poles is achieved by the contraction of chromosomal fibres and the stretching of interchromosomal fibres. At the end of anaphase two groups of chromosomes are seen.
4. *Telophase* (Gk. *telos*—end, *phasis*—stage): This is the last stage of nuclear division in which reconstruction of the daughter nuclei takes place. The chromosomes which reach the opposite poles of the cells now elongate and become thread-like in nature. The nucleolus reappears and the astral rays disappear. The elongated chromosomes overlap one another and give rise to the chromatin reticulum. Each chromosome group is changed into a nucleus by the formation of a membrane around the chromatin reticulum.

CYTOKINESIS

Cytokinesis or division of the cytoplasm begins in the anaphase and is completed after the end of telophase. In the process of cytokinesis the cytoplasm splits in the equatorial region and the two daughter halves of the cytoplasm are separated. Soon after this, a unit membrane of lipoprotein develops between the two daughter cells.

3.8 Significance of mitosis

1. Mitosis helps the cell in maintaining its proper size.
2. It provides an opportunity for the growth and the development of organs in multi-cellular organisms.
3. Due to mitosis the old cells are replaced by new cells.
4. In mitotic division, the chromosome number in each daughter cell remains the same as the parent cell.
5. Mitosis helps the organisms in asexual reproduction.
6. The gonads and the gametes depend on mitosis for the increase in their number.
7. Through the process of mitosis an equilibrium in the amount of DNA and RNA contents is maintained.

Some basic concepts

1. The *cell* is the basic unit of life.
2. Cells are usually uninucleate, (having a single nucleus). The cells of certain organisms contain more than one nucleus. They are called *multinucleate*.
3. The new cells arise from the existing cells by *division*.
4. *Mitosis* is the most common mode of cell division in plants and animals and is also called somatic cell division.

Some suggested projects / activities

1. *Prepare a model of an animal cell with the help of wires, colour buttons, beads, etc.*
2. *Prepare a chart showing chromosome numbers of common plants, animals and man.*
3. *In groups prepare models of various stages/phases of mitosis using plastic clay.*

REVISION

CELL

I *Choose the correct answer.*

1. The cell theory was propounded by
   a. M.J. Schleiden and T.Schwann. b. J.D.Watson and F.H.C.Crick.c.G.W. Beadle and E.L.Tattum. d. R. Feulgen and H.Rossenbeck.
2. The mitochondria
   a. are structures in the nucleus. b. are the initiators of cell division. c. are centres of cell respiration. d. have no known function.
3. The main controlling centre of the cell is the
   a. nucleolus. b. nucleus. c. ribosome. d. Golgi body.
4. Protein synthesis occurs
   a. in the DNA b. in the RNA c. in the ribosomes. d. in the Golgi bodies.
5. The organoid which is rich in hydrolytic enzymes is
   a. mitochondria. b.Golgi complex. c. lysosomes. d. ribosomes.

II *State whether true or false.*

1. The most abundant compound found in living tissue is water.
2. Many proteins function as enzymes, i.e. they facilitate chemical reactions.
3. Both organic and inorganic materials are required by living organisms.
4. The cell is the basic unit of life.
5. All cells have cell walls.
6. Ribosomes appear to function as centres for protein synthesis in the cell.
7. Multicellular organisms arise from the pre-existing organisms only.

III *Fill in the blanks.*

1. The inner folds of the mitochondria are known as _______________
2. DNA is found in the _______________ .
3. Golgi complex is found in the _______________ of a cell.
4. Man has _______________ chromosomes.
5. Leucoplasts are _______________ plastids.

6. The plasma membrane is ______________ permeable in nature.
7. Ribosomes may be found attached to the ______________ .
8. Ribosomes are the seat of ______________ .
9. A group of similar cells performing the same function is called a ______________ .
10. ______________ are the power houses of the cell.

IV *Answer the following questions. Draw diagrams where necessary.*

1. Who was Robert Hooke? How is he connected with the cell?
2. Describe the structure of a chromosome.
3. Give an account of the cell organelles.
4. What are the functions of mitochondria, chloroplasts, nucleolus and vacuoles?
5. Enumerate the differences between plant and animal cells.
6. Draw a neat labelled sketch to show the structure of an animal cell as seen under an electron microscope.

CELL DIVISION:

V. *Choose the correct answer.*

1. The spindle formation begins in the
   a. prophase. b. metaphase. c. anaphase. d. telophase.
2. The chromosomes get themselves arranged in the equatorial plate during the
   a. metaphase. b. prophase. c.anaphase. d. telophase.
3. Which stage is just the opposite of prophase?
   a. anaphase. b. interphase. c. metaphase. d. telophase
4. Meiosis is biologically significant because
   a. it halves the chromosome number. b. it requires two steps. c. most cells divide mitotically. d. most growth occurs this way.

VI *Answer the following questions.*

1. What is cytokinesis?
2. Name the different stages of mitosis.
3. What is the significance of mitosis?

VII *Write notes on.*

1. Interphase. 2. metaphase. 3. telophase.

VIII *Distinguish between*

a. mitosis and amitosis b. meiosis and mitosis c. prophase and telophase
d. karyokinesis and cytokinesis.

4. Nutrition and hygiene

Nutrition and hygiene - role of enzymes in digestion - pathogenic forms - role in human health - mode of infection - aflatoxins - food poison - a. Entamoeba b. Ascaris -production of aflatoxins - contamination of food.

4. Nutrition and hygiene

Many diseases and toxicities are caused by neglect of sanitation and unhygienic handling of food stuff. Therefore, some knowledge of food hygiene and sanitation is a must for every person. It will be useful to know how our food gets contaminated with harmful substances and organisms, the effect this has on us, and learning about methods of preventing the same.

4.1 Role of enzymes in digestion

Enzymes are *biocatalysts* which control the metabolic reactions of an organism. In their functions they resemble catalysts but differ from them in being sensitive to temperature and poison. Enzymes contain proteins. The molecule of each enzyme has one or more small areas called *active sites.* At these sites, the reactants come together for a chemical change.

There are different kinds of enzymes responsible for different chemical activities in the body. Some of the activities are:

a. Digestion of food by *hydrolysing* of *digestive enzymes*

b. Changing of excess of food substances into a form in which they can be stored in the body, e.g., if our diet includes excessive carbohydrates, the digested excess is changed into glycogen and stored in the liver and muscle cells. This change is brought about by enzymes called *condensation enzymes.*

c. Releasing of energy from food during the process of respiration with the help of *respiratory enzymes.*

In short, all the metabolic, chemical reactions going on in the living cells, are controlled by enzymes.

PROPERTIES OF ENZYMES

The main characteristics shared by *all* enzymes are:

1. They work within a narrow *range of temperature* between 35 - 40°C. They become inactive or are destroyed at high temperatures, and the reactions which they control are gradually slowed down when the temperature decreases below this range.

2. They act as catalysts within living cells speeding up the chemical reactions occurring in them and are therefore called biocatalyst. Like chemical catalysts, a small quantity of an enzyme is sufficient to bring about a large amount of chemical change.
3. They react only in a suitable medium, which has a particular degree of *acidity* or *alkalinity*.
4. The action of any particular enzyme is *specific*, i.e., it acts only on one kind of substance. For example, proteases act only on protein and will not act on carbohydrates or fats and oils.
5. They are required only in small quantity and each enzyme always produces the same end-product.

Activity 1: *Prepare a table which clearly shows the vital part played by enzymes during digestion.*

4.2 Pathogenic forms

Disease - causing agents are known as pathogens. Parasites of the groups protozoans, platyhelminthes, nematodes and arthropods infect man and his livestock and cause enormous damage. Several people who have been parasitised die prematurely, whereas many others suffer from severe, death-like, disfiguring or debilitating diseases.

Entamoeba histolytica

Entamoeba histolytica, is one of the well-known parasites which lives in man. It is universal in distribution but high incidences of human infection have been reported from the topics. The uninuclete organisms measures 20-50μ in diameter and moves by the formation of a single large pseudopodium. They contain a nucleus and their cytoplasm which is differentiated into ecto and endoplasms, possesses blood corpuscles and epithelial cells. Unlike other intestinal protozoans, Entamoeba histolytica does not nourish itself on the contents of the intestine. Instead it actively sucks the cells and the tissues of the host.

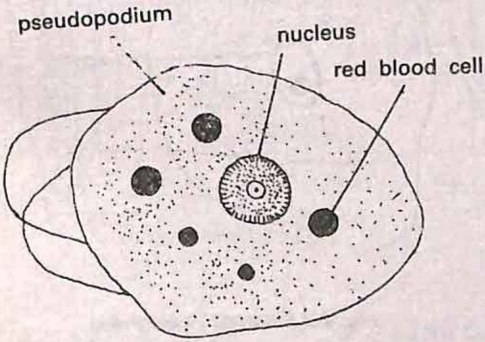


Fig. 4.1 Structure of Entamoeba histolytica

Life cycle

Since only the amoebic cysts can cause the transmission hazards, some of the intestine-inhabiting organisms, from time to time pass on to the cystic forms.

Animals become infected with this parasite when the water or food containing Entamoeba histolytica cysts, is ingested by the host. These cysts can cause infection more readily if ingested along with water than with food. This is possible due to the greater rapidity with which the cysts pass through the stomach. After passing the stomach region, a tetranucleate organism emerges from each structure. This amoeba then, undergoes cytoplasmic division to produce small, uninucleate *trophozoites,* which later on pass into the large intestine and matures.

In many cases, after the invasion of mucous membrane of the large intestine, they reach to sub-mucosa and form ulcers. Sometimes the amoebae may reach the blood from where they

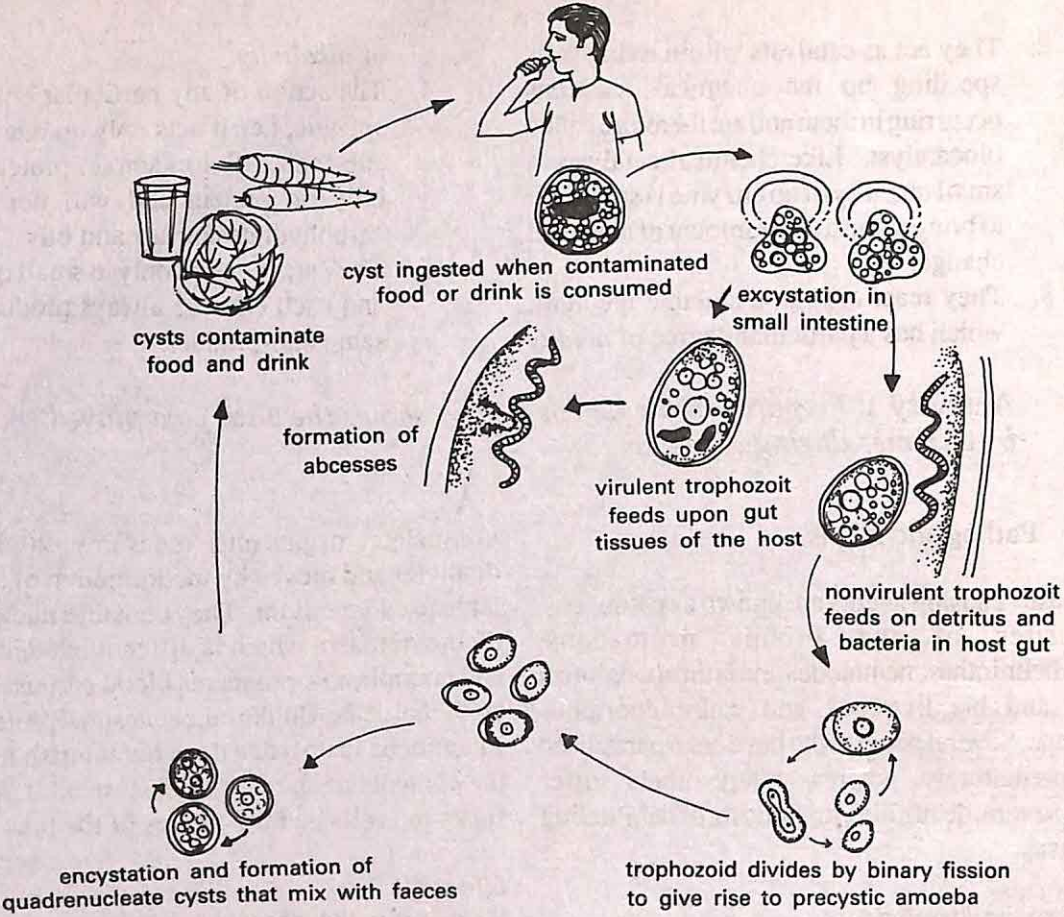

cyst ingested when contaminated food or drink is consumed
excystation in small intestine
cysts contaminate food and drink
formation of abcesses
virulent trophozoit feeds upon gut tissues of the host
nonvirulent trophozoit feeds on detritus and bacteria in host gut
encystation and formation of quadrenucleate cysts that mix with faeces
trophozoid divides by binary fission to give rise to precystic amoeba

Fig. 4.2 Life cycle of Entamoeba histolytica

may be carried to the liver, lungs, brain or genital organs. In the liver as well as in the other organs, the trophozoites develop *abscesses*. The patient shows abdominal pains, chronic fatigue, headache, and other non-specific symptoms of ill-health.

Entamoeba gingivalis.

This an amoeba found in the mouth of man. It is sometimes found associated with *pyorrhoea*, through it is not considered the primary cause of the disease.

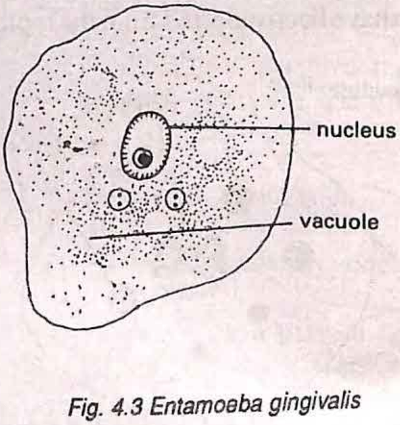


Fig. 4.3 Entamoeba gingivalis

Activity 2: *Observe the prepared slides of Entamoeba histolytica and Entamoeba gingivalis under a microscope and draw neat labelled sketches.*

ASCARIS LUMBRICOIDES

The female Ascaris lumbricoides have a length of 8 - 14 inches with a diameter of 4 - 6 mm. The males are only 6 to 10 inches long but they are more slender than the females. The females are also distinguishable by the blunt tail, whereas the males have a curved tail with an anal opening from which a pair of penial spicules often protrudes. In both the sexes, the head is slender and the mouth is guarded by three lips, one dorsal and two subventral. Each lip has minute papillae on its outer surface, while the inner surface bears hard ridges.

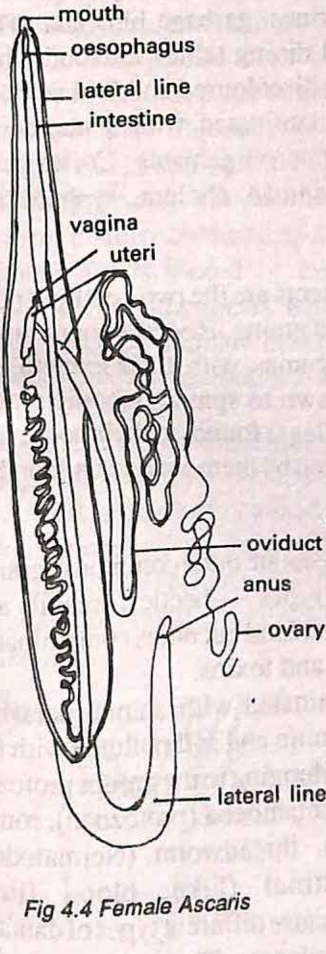


Fig 4.4 Female Ascaris

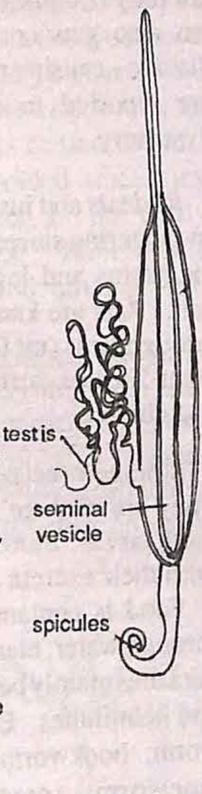


Fig. 4.5 Male Ascaris

Life cycle and mode of infection

The shelled eggs (embryos) leave the mammalian host in faeces and their further development requires suitable environmental conditions such as moisture, temperature, etc. At about 30° C or even lower temperatures the embryos develop into coiled *larvae* capable of infecting the mammalian host within 15 days. However, it is well known that the shelled eggs of Ascaris lumbricoides may remain viable (effective) for several years in cold and dry atmosphere.

Infection of the vertebrate host is direct and the most common mode of infection in man is by

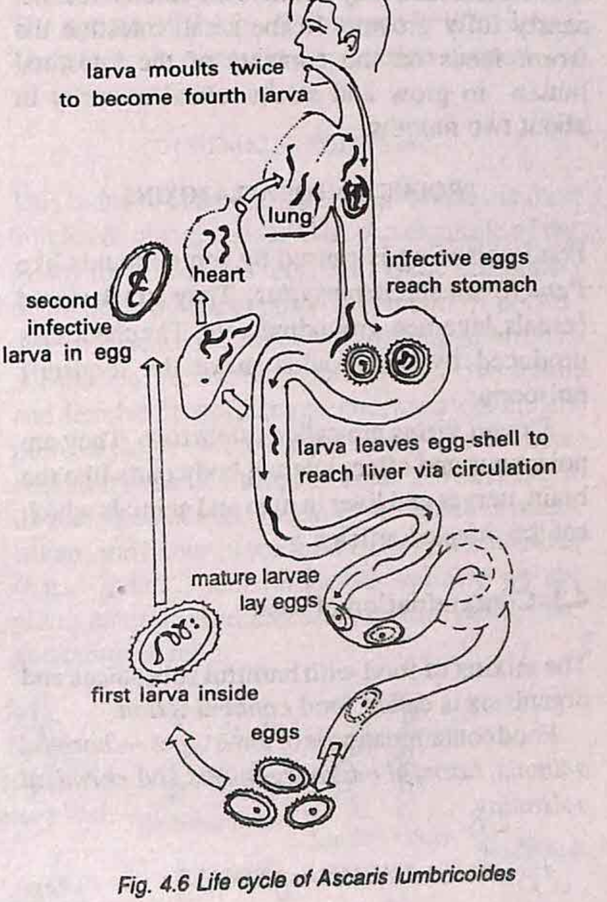

larva moults twice to become fourth larva
lung
heart
infective eggs reach stomach
second infective larva in egg
larva leaves egg-shell to reach liver via circulation
mature larvae lay eggs
first larva inside eggs

Fig. 4.6 Life cycle of Ascaris lumbricoides

Activity 3: *Observe preserved specimens of male and female Ascaris lumbricoides. Write a short note on its life cycle and mode of infection.*

swallowing infective eggs along with food or drinks containing them. These eggs are not infective until they hatch in the duodenum. After they emerge from the shell, the young larvae, penetrate the mucosa and pass into the blood stream and eventually migrate to the liver. From here, they reach the heart and lungs. During this journey, they increase in length about ten-fold from their initial length.

After about seven to eight days of post-infection (after infection) the larvae break out of the capillaries into the alveoli and then reach the trachea and the pharynx.

Here, they may be swallowed along with the sputum and thus they return to the small intestine, nearly fully grown. In the small intestine the worm feeds on the contents of the intestinal lumen to grow and attain sexual maturity in about two months.

PRODUCTION OF AFLATOXINS

Food poisoning is caused by some moulds like *Penicillium* and *Aspergillus*. They attack stored cereals, legumes, groundnuts, etc. The chemicals produced by the moulds make the foodstuff poisonous.

Fungal toxins are called *aflatoxins*. They are poisonous and affect internal body parts like the brain, nerves and liver in man and animals which eat the infected articles.

4.3 Contamination of food

The mixing of food with harmful substances and organisms is called food *contamination*.

Food contamination is of three types — *harmful animals*, *harmful microorganisms* and *chemical poisoning*.

1. HARMFUL ANIMALS

A number of different kinds of animals cause food contamination. They are houseflies, cockroaches, storage pests and animal parasites.

Houseflies are the most dangerous source of food contamination because they visit all sorts of places and lay eggs on faecal matter and organic debris of other types. Their bodies are hairy and therefore, carry all types of microorganisms, eggs and larvae of different human parasites on them. These are deposited on exposed utensils and food, etc. Houseflies may also sit on our clothes, body and towels through which contamination may spread. In this way houseflies are known to spread diseases like cholera, typhoid, dysentery, diarrhoea, conjunctivitis, etc.

Cockroaches live in all types of places where organic food is available. They often hide themselves in latrines, garbage bins etc. They visit kitchens and dining tables for food which not only becomes discoloured and foul smelling but also gets contaminated with a number of disease - causing microorganisms. Cockroaches are reported to spread cholera, typhoid and dysentery.

Rodents and insects are the two common pests endangering stored grains. Rodents contaminate the grains and legumes with their excreta and hair. Rats are known to spread bubonic plague through fleas (rat fleas) found on their body. The other diseases carried by them are typhus, jaundice and cholera.

Storage insect pests are quite common in grains. They are of three types — beetles, weavils and moth larvae. Stored food becomes contaminated with their excreta and toxins.

Food is contaminated with animal parasites through water, manure and soil polluted with the parasites mainly belonging to the groups protozoa and helminthes. Entamoeba (protozoan), round worm, hookworm, threadworm (Nermatodes) tapeworm, intestinal fluke, blood fluke (platyhelminthes) cause different types of damage to the intestine and viscera. The major reasons of the spread of these diseases is the improper washing and cooking of foodstuff.

2. HARMFUL MICROORGANISMS

They include fungi, bacteria and related organisms. Microorganisms are microscopic. They cannot be observed easily till they have spoiled the food. Microorganisms enter the food through air or soil borne spores and contaminated containers. Contamination occurs in all types of foods — cereals, legumes, fruits, bread, jams, pickles, etc.

The spoilage of food by bacteria is called *bacterial rot.* Milk becomes sour because of *Lactobacillus. Pseudomonas* produces a slimy layer over the surface of liquid foods.

Rhizopus, Penicillium and *Aspergillus* cause vegetables fruits, jams and pickles to rot. *Fungal rot* can be distinguished from bacterial rot by the presence of coloured spots and fine cottony or coloured threads. In bacterial rot, the food stuffs simply becomes soft or slimy. Sugary syrups are spoiled by yeasts, *(Saccharomyces)* which do not form distinct coloured spots or fine threads.

Rotten foods should be avoided since they contain several chemicals which are not easily metabolised by human beings. Their intake produces vomitting, nausea and other gastro-intestinal disorders.

Many disease-causing microorganisms spread through infected food. *Mycoses* (fungal diseases of internal organs) are caused mostly by eating rotten foods. The bacterium that causes tuberculosis is *Mycobacterium tuberculosis* which is spread from infected cattle through improperly boiled milk.

FOOD POISONING

Some microorganisms produce toxins (poisons) during their metabolism. The most common type of food poisoning is due to *Staphylococcus* which is quite common on the exposed parts, nose and throat of the human body. They also occur in boils and pus. The bacteria pass from infected persons into the food where they grow rapidly and produce *enterotoxins* within few hours. The toxin is not destroyed by heating or cooking. A more dangerous and fatal food poisoning called botulism is produced by *Clostridium botulinum .* The bacterium occurs in the soil and contaminates all types of vegetables and exposed food articles. The spores of the bacterium are heat resistant. Therefore, they remain alive inside canned and other types of stored food.

3. CHEMICAL POISONING

This is due to chemicals produced inside the food articles or outside chemicals. An example of the toxins formed by the food stuff is the formaltion of *solanine* by the exposed green part of potato-tubers. The toxin produces vomitting, diarrhoea and nausea. Acidic foods have a corrosive action and dissolve tin and damage other metal containers more rapidly. Mercury poisoning has become common in some European countries because of its increased concentration in the Mediterranean ocean, and hence in sea foods. Some insecticides (e.g., D.D.T.) and fungicides sprayed on the plants enter food articles and cause mild or severe poisoning in man.

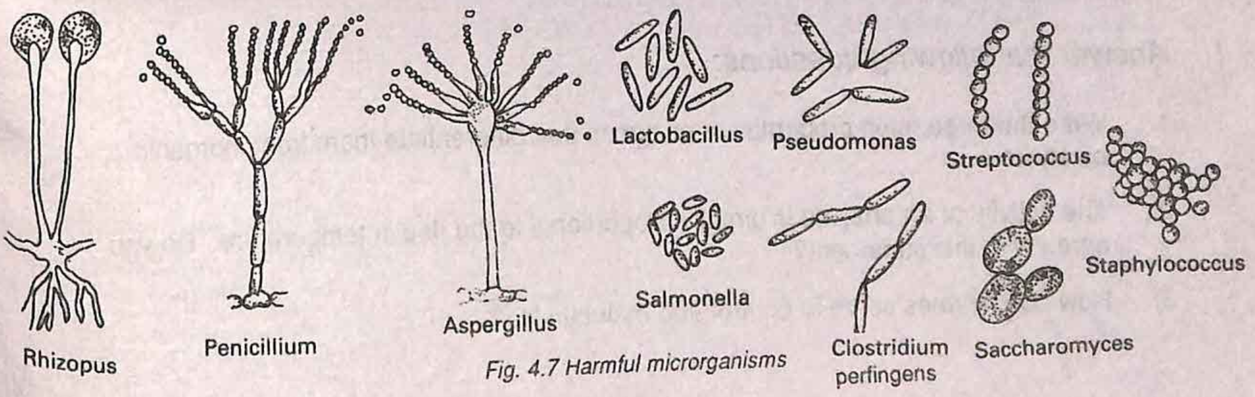


Fig. 4.7 Harmful microrganisms

FOOD SANITATION

Safe and hygienic handling of food stuffs is called *food sanitation*. The kitchen, store room and dining room should be kept free from household pests. All utensils and tableware should be properly washed, rinsed and dried.

Cooked food should not be left uncovered. Creams, milk, puddings, etc. should be consumed immediately after preparation. For storage of acidic foods, tin or copper utensils should not be used. It is always preferable to store food in vessels made of glass, china, stainless steel, aluminium, etc.

Some basic concepts

1. Some knowledge of food hygiene is a must for every person.
2. Enzymes act as biocatalysts and control metabolic reactions of an organism.
3. The study of disease is known as pathology and the disease causing agents are known as pathogens.
4. Food is contaminated by harmful animals, harmful microorganisms and chemicals.
5. Care must be taken while preparing and storing food to avoid exposure to disease - producing organisms.

Some suggested projects / activities

1. *Observe prepared slides of Entamoeba species, liver fluke, tapeworms, pinworms, threadworms, Ascaris etc. Classify them as protozoan, nematode and helminth (flatworms) parasites. Write their parasitic adaptations in two or three lines.*
2. *Visit a health centre and find out more about contamination of food and the care of patients suffering from taking in such foodstuff.*

REVISION

I *Answer the following questions:*

1. Write the three main properties of enzymes that differentiate them from inorganic catalysts.
2. The activity of an enzyme is directly proportional to the rise in temperature. Do you agree with this statement?
3. How do enzymes serve to control and maintain life?

I Answer the following questions.

1. What is pathology?
2. Name some pathogenic forms.
3. Name two protozoan parasites.
4. Write about Ascaris and its mode of infection.
5. Differentiate between Entamoeba histolytica and Entamoeba gingivalis.

III Answer the following questions.

1. What is food contamination? Name the sources of food contamination.
2. What is food poisoning? How is it caused?
3. Why is the cockroach (or housefly) a source of the spreading of so many diseases? Name four animal parasites.
4. What is the causal agent of plague?
5. Why should acidic food not be kept in copper, tin or brass containers?
6. Suggest steps to keep hygienic conditions in the kitchen.

IV Write notes on:

a. harmful animals. b. harmful microorganisms. c. aflatoxins. d. chemical poisoning. e. food sanitation. f. properties of enzymes.

5. Reproduction, inheritance and evolution

Physical basis of heredity - (DNA) - chromosomes - (genes) DNA and RNA - significance - structure - chemical structure of nucleic acids - difference in biochemical organisation - evolution as a process - origin of life - descent - modifications - formation of new species - genetic variation, perpetuation - inheritance and isolation - theories of evolution - evidence - experiments - evidences from comparative anatomy - progressive complexity - palaeontology - embryology - heredity and variation - causes and types.

The development of each living organism follows a 'blueprint' inherited from its parents. If reproduction required only one parent; then the offspring would inherit one set of genes, and would resemble his parent in every detail.

In sexual reproduction, however, each new individual inherits two sets of genes, one from each parent. He is different from both parents, having inherited some traits from one and another set of traits from the other. The main advantage of sexual reproduction is that offsprings inherit a variety of traits from their parents.

Activity 1: *In groups, discuss, the human characteristics which are developed mainly due to passing on of genes from parents to offspring and others that are formed by the influence of the environment.*

5.1 Physical basis of heredity

The scientist Mendel identified 'factors' (genes) as being responsible for physical characteristics. Genes are the structural and functional units of chromosomes, and are transferred from the parents to the offspring during reproduction.

In sexually reproducing organisms, the germ cells divide by meiosis to form *gametes*. The number of chromosomes in each gamete is reduced to half of that in the parent cell. The genes present in the parent cell duplicate only once during meiosis and are subsequently distributed in equal numbers to the gametes. During fertilisation, when the male and female gametes fuse to form a *zygote*, the number of chromosomes in it is restored to the parental number. Hence, the new organism that develops from the zygote receives half the number of chromosomes, (containing genes) from each parent.

THE GENETIC MATERIALS —CHROMOSOMES AND GENES

There is ample evidence that the chromosomes

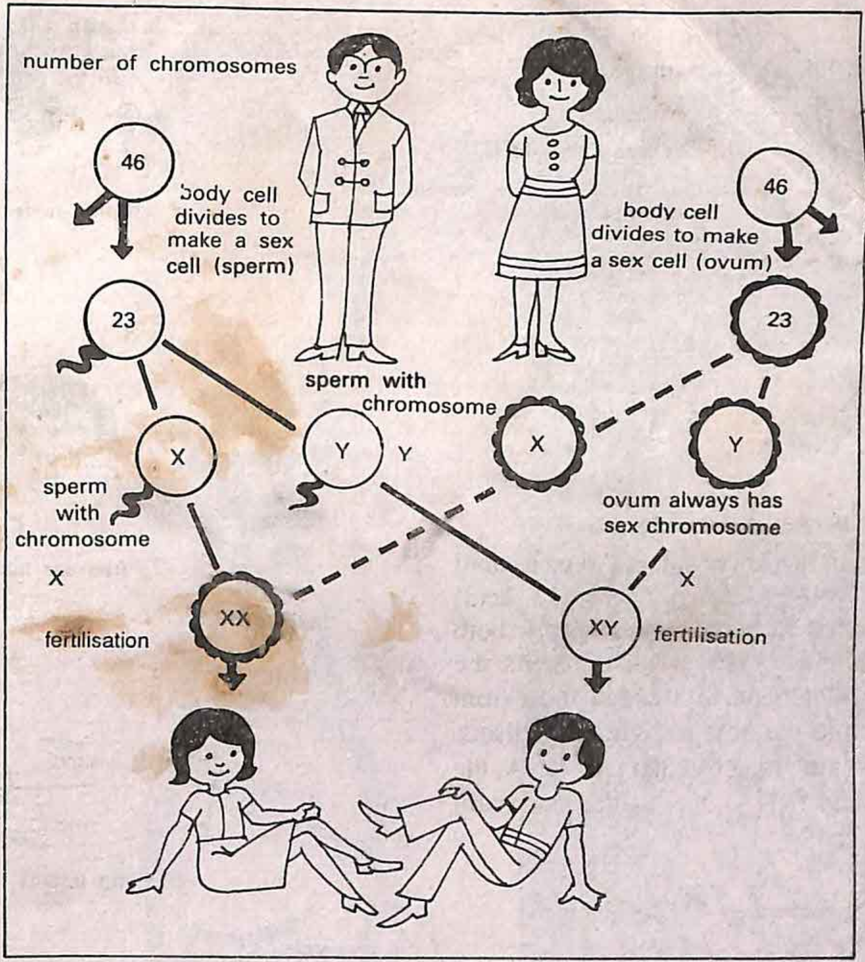

number of chromosomes
46
body cell divides to make a sex cell (sperm)
46
body cell divides to make a sex cell (ovum)
23
23
sperm with chromosome
Y
X
Y
X
Y
sperm with chromosome
X
ovum always has sex chromosome
X
XX
fertilisation
XY
fertilisation

Fig. 5.1 How sex is inherited

contain genes that are the ultimate units of heredity. All organisms of a particular species carry the same number of chromosomes, e.g., 46 in man, 78 in dog and so on. The chromosomes may be differentiated into *autosomes* (all chromosomes other than sex chromosomes) and *allosomes* (sex chromosomes) which are referred to as X and Y chromosomes in bisexual organisms.

Activity 2: *The human egg cell is larger than the sperm. Does this imply that the child inherits more from the mother than from the father? Find out more about this.*

The structure of a chromosome:

Each chromosome has an outer limiting membrane called the *pellicle*. The two arms of a chromosome are joined together by a constricted region called the *centromere*. Two spirally coiled filaments known as *chromonemata* are embedded internally in a ground substance known as the *matrix*.

The chromosomes bear the hereditary units *genes* which control the different characteristics of an organism, its height, colour, hair, etc.

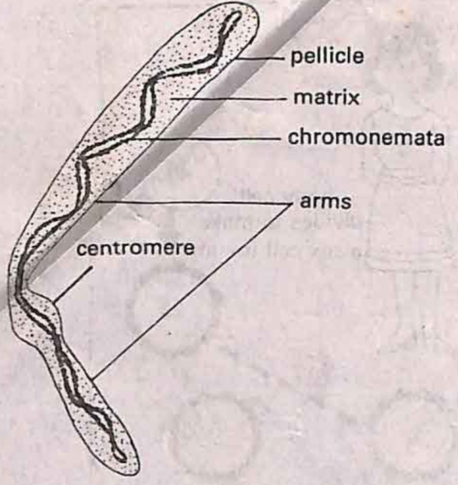


Fig 5.2 The structure of a chromosome

Gene: A gene, in fact is considered to be a small part of the DNA (deoxyribo nucleic acid) molecule, which is the hereditary material in both plants and animals. The DNA transmits the hereditary characteristic in a coded form from one generation to the next in living organisms. However, in some viruses which lack DNA, the ribo nucleic acid (RNA) acts as the hereditary material.

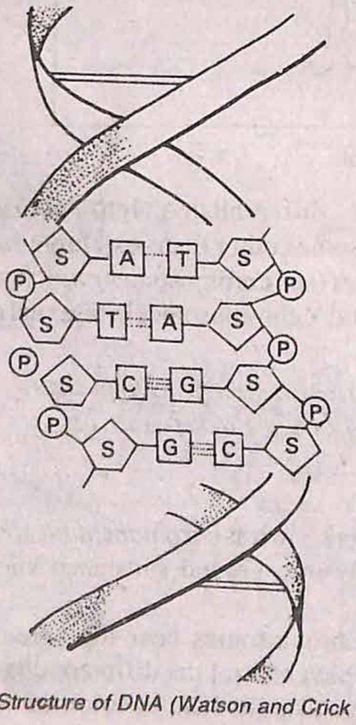
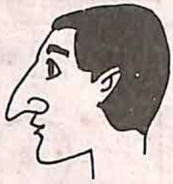
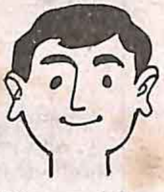


Fig. 5.4 Structure of DNA (Watson and Crick model)



roman nose



free ear lobes

very long fingers

very short fingers

Fig. 5.3 Some genetic traits

5.2 Chemical structure of nucleic acids

STRUCTURE OF DEOXYRIBO NUCLEIC ACID (DNA)

A model of the DNA structure was proposed by *Watson* and *Crick* in 1953. According to them, a DNA molecule has a *double helix,* i.e., it is

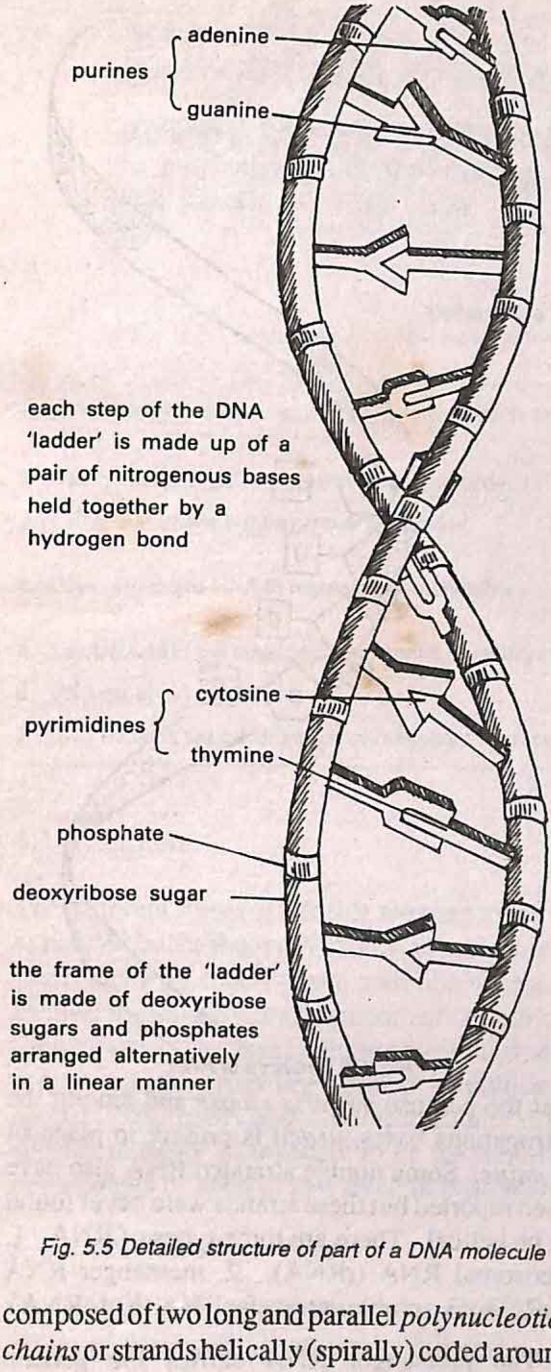

purines
adenine
guanine
each step of the DNA 'ladder' is made up of a pair of nitrogenous bases held together by a hydrogen bond
pyrimidines
cytosine
thymine
phosphate
deoxyribose sugar
the frame of the 'ladder' is made of deoxyribose sugars and phosphates arranged alternatively in a linear manner

Fig. 5.5 Detailed structure of part of a DNA molecule

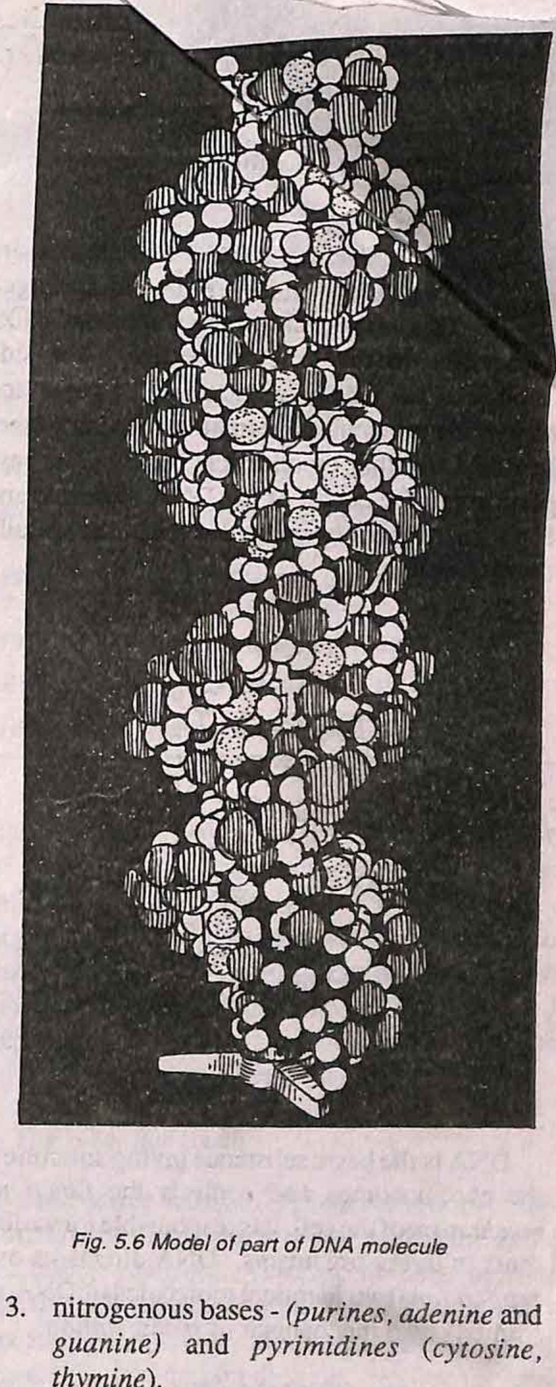


Fig. 5.6 Model of part of DNA molecule

composed of two long and parallel *polynucleotide chains* or strands helically (spirally) coded around the same axis like a spiral ladder. There may be thousands of turns in the spiral.

The nucleotides in each chain consists of

1. pentose sugar (deoxy ribose)
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Among these bases, adenine pairs specifically with thymine, and cytosine with guanine. Hence, the sequence of bases in one polynuleotide chain of the DNA molecule is dependent on the sequence

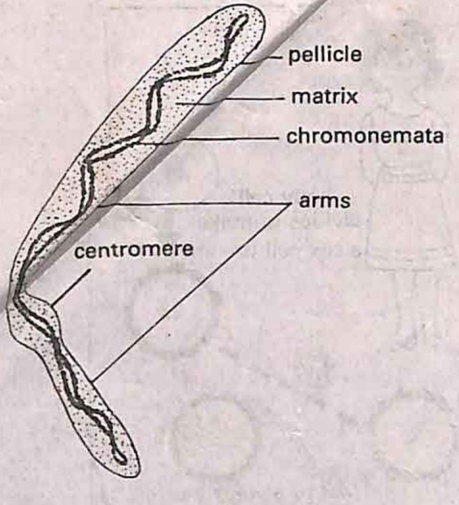

Fig 5.2 The structure of a chromosome

Gene: A gene, in fact is considered to be a small part of the DNA (deoxyribo nucleic acid) molecule, which is the hereditary material in both plants and animals. The DNA transmits the hereditary characteristic in a coded form from one generation to the next in living organisms. However, in some viruses which lack DNA, the ribo nucleic acid (RNA) acts as the hereditary material.

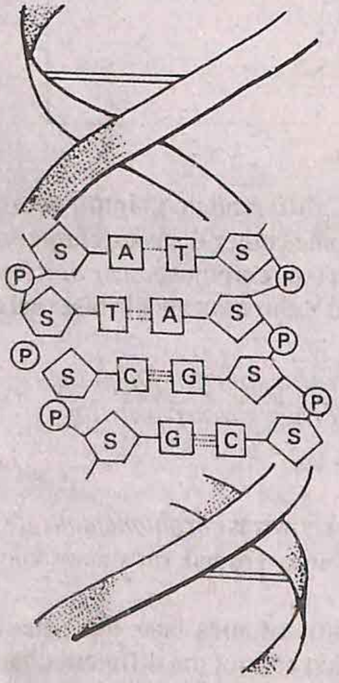

Fig. 5.4 Structure of DNA (Watson and Crick model)

roman nose

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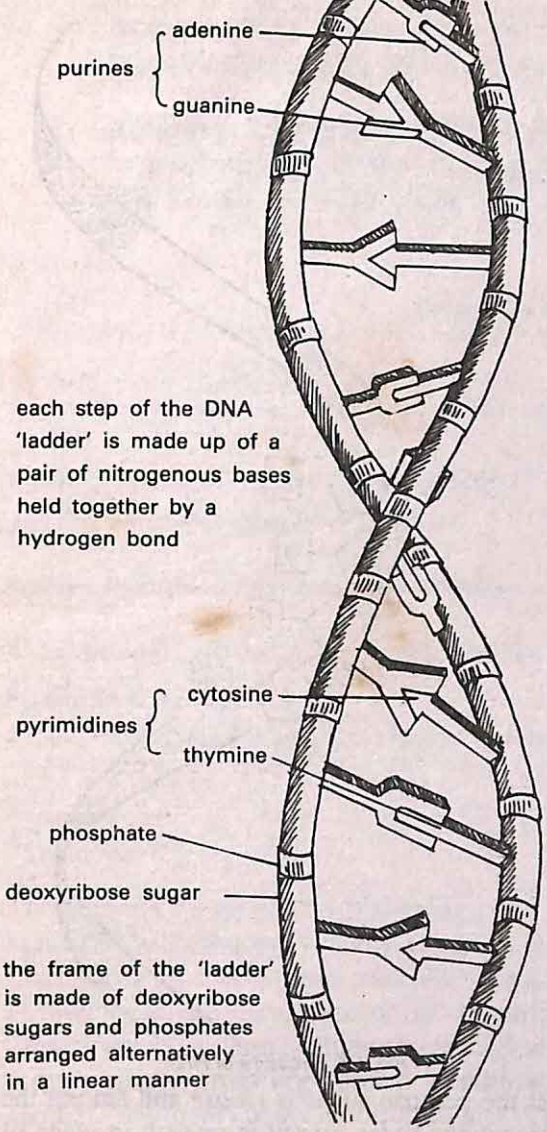
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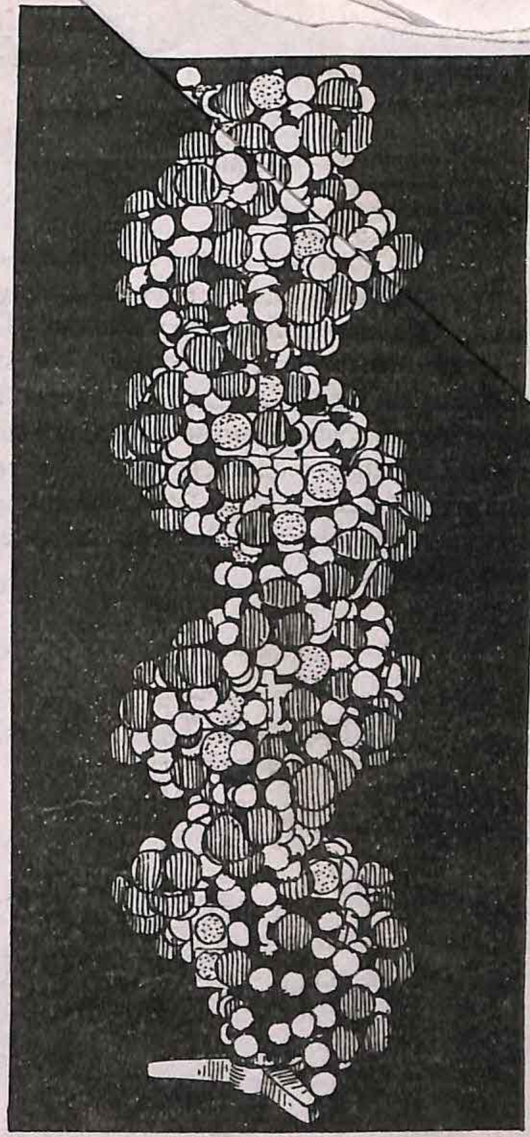

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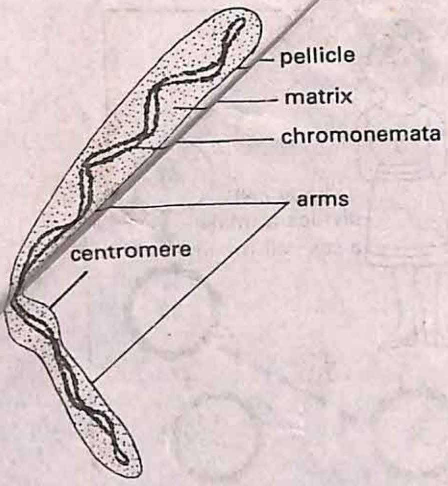

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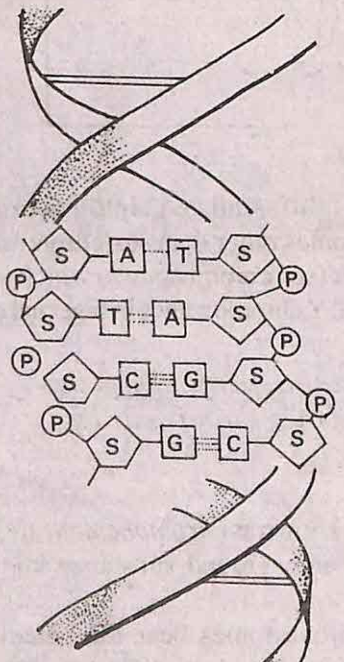
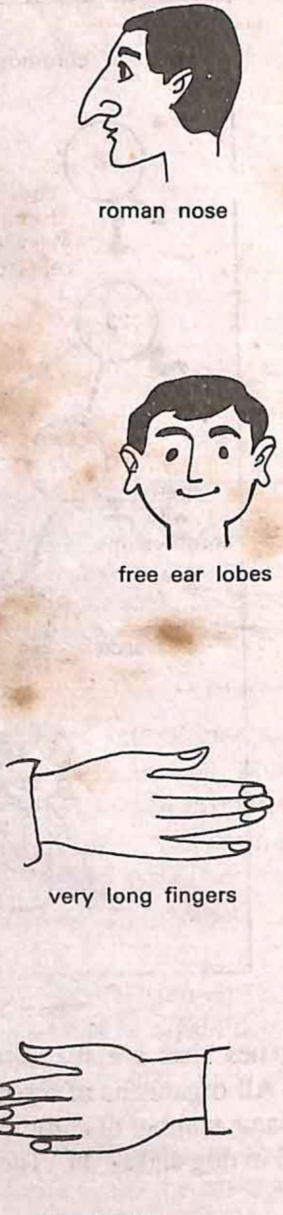


Fig. 5.4 Structure of DNA (Watson and Crick model)



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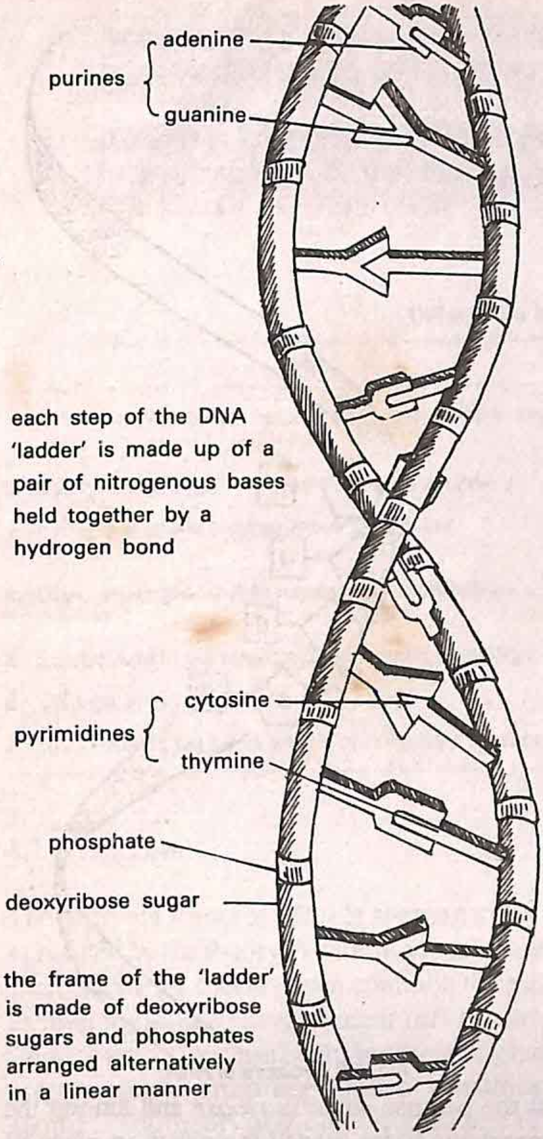
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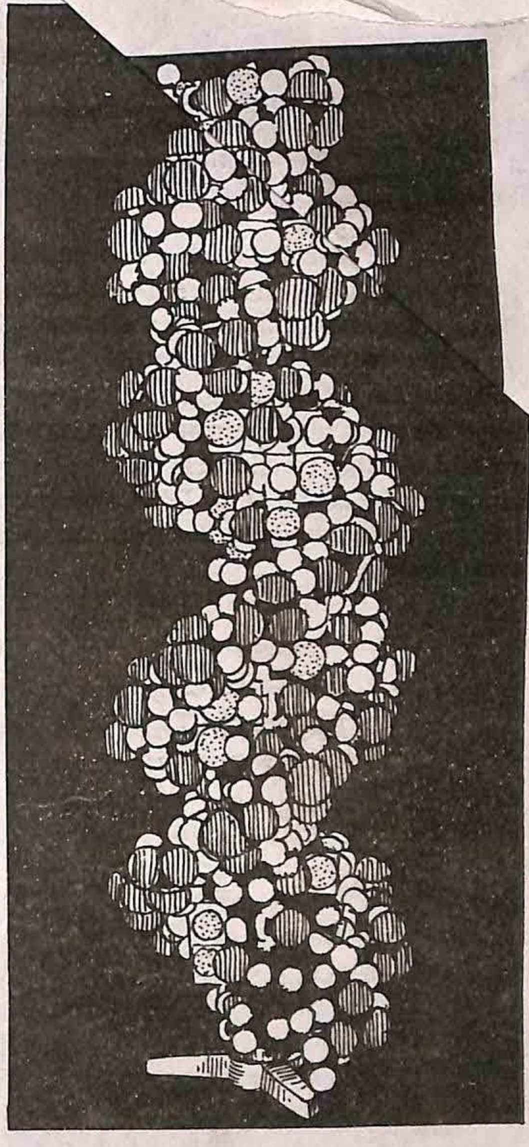

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Among these bases, adenine pairs specifically with thymine, and cytosine with guanine. Hence, the sequence of bases in one polynuleotide chain of the DNA molecule is dependent on the sequence

of bases in the other. The two chains are, therefore, said to be complementary to each other.

I chain: thymine guanine cytosine, thymine guanine thymine
II chain : adenine cytosine guanine adenine cytosine adenine

The base molecules of the two chains are linked through a large number of *weak hydrogen bonds*. This arrangement gives a ladder - like appearance to the DNA molecule. The side railings of the ladder are made up of *sugar* and *phosphate* molecules alternating with each other and held together by chemical bonds. The base pairs are in the centre of the DNA molecule and form the rungs or horizontal steps of the spirally twisted ladder.

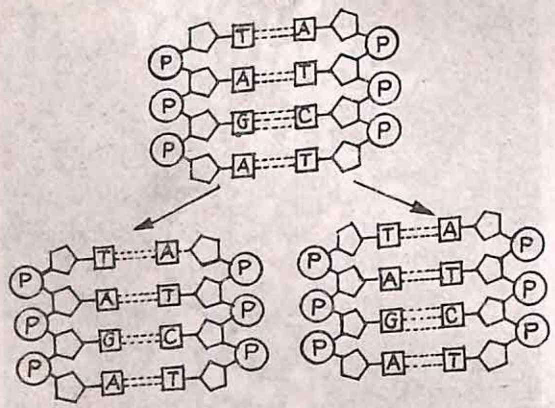

Fig. 5.7 DNA replication

DNA is the basic substance giving structure to the chromosomes and controls the *functional mechanism* of the cell. It is responsible for various traits in living organisms. DNA directs its own *replication* (two identical molecules of DNA are formed) by a mechanism of *transcription.*

RIBO NUCLEIC ACID (RNA)

The RNA molecule has generally a single strand of unbranched polynucleotide chain. Its constituents are the same as in the DNA except

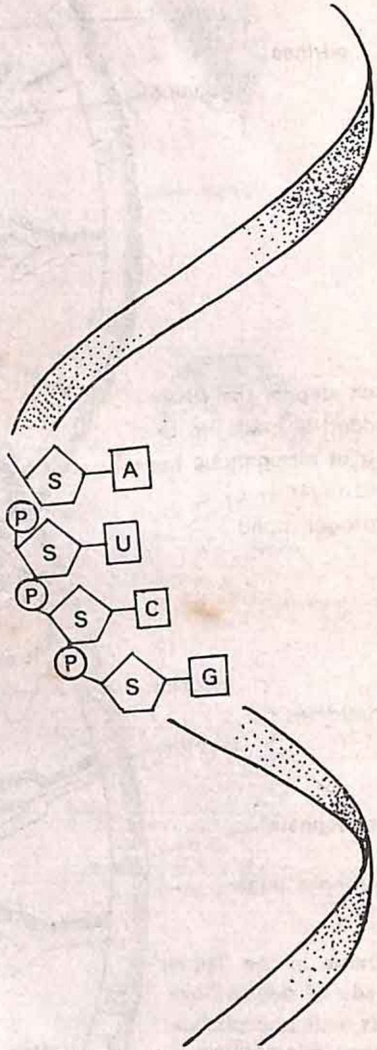

Fig. 5.8 Structure of RNA

that the pentose sugar is *ribose* and among the nitrogenous bases, *uracil* is present in place of *thymine*. Some double stranded RNA also have been reported but these strands were never found to be helical. There are three types of RNA. 1. ribosomal RNA (rRNA), 2. messenger RNA (mRNA), 3. soluble or transfer RNA.(S or tRNA).

The messenger RNA carries the genetic information. RNA is mainly concerned with protein synthesis and enzymatic activities of metabolism in cells. It receives coded information from the DNA and does the work of *translation* resulting in the formulation of specific proteins.

Activity 3: *In groups, prepare a* dialogue *betw*
bringing out the salient features of each. *NA and RNA*

Activity 4: *Prepare models of the structure of DNA an*
help of coloured beads, buttons, plastic wires and iron or *with the*
filaments (or) wires. *nium*

Differences between DNA and RNA

DNA	*RNA*
1. It consists of a double helix of two polynucleotide chains.	It consists of only one helix of single polynucleotide chain.
2. Deoxy ribose sugar is present in the nucleotide.	Ribose sugar is present in the nucleotide.
3. Pyrimidine bases are thymine and cytosine.	Uracil base is present instead of thymine. Cytosine is the second pyrimidine base.
4. DNA synthesize RNA to regulate cell metabolism	RNA is synthesized by DNA and carries information from the DNA to regulate the cell metabolism.
5. The DNA form the main genetic material of eukaryotes.	RNA is the genetic material of plant viruses.
6. DNA occurs in one form only.	RNA occurs in three forms. (m RNA, r RNA and t RNA)
7. DNA controls the transmission of hereditary characteristics.	RNA controls synthesis of proteins in the cell.

5.3 Evolution

The different forms of life that are seen today are explained by the theory of evolution as *descent* of each and every species from common ancestors. Evolution is the development of organisms through time. The term evolution means a gradual orderly change from one form or condition to another. The theory of evolution considers all the species in today's biosphere to be the modified descendants of species that lived in past years.

5.4 Evolution as a process

The present concepts of chemical evolution and origin of life can be discussed as follows:

ORIGIN OF LIFE

1. The origin of environment:

It has been suggested by scientists that the planet Earth may have originated from the condensation of extremely hot gaseous material or a molten mass, both derived from some other heavenly body. It cooled slowly and gradually compressed due to gravitational forces. An atmosphere, which retained water finally prevailed. The water filled depressions on the surface to form oceans. These originally may have been very hot.

2. The primitive earth:

By radioactive dating of ancient rocks both of the earth and of the moon, it is agreed that the earth is 5 billion years old. Most recent ideas indicate that the atmosphere of primitive earth contained free nitrogen, hydrogen, hydrogen cyanide, carbon monoxide, and carbon dioxide. No free oxygen was present in the primitive atmosphere. Oxygen did not appear in free form until well after the development of life and the evolution of photosynthesising cells.

es:

3. Formation of organic organic compounds

The gaseous mixtu atmosphere of the earth present in the pri getting energy either from reacted togeth ultra violet radiations. These lightning or ons, thus formed simple organic chemical like amino acids, nucleotides, fatty comp . These organic compounds were aci ed in the earth along with rain water and a the biochemical evolution of simple molecules into more complex ones started.

4. Origin of eobionts:

The simple compounds accumulated in the primitive oceans to form what we now call the "organic soup". These compounds reacted chemically to form two types of macromolecules or primitive cell-like structures — 1. protein spheroids 2. large molecules aggregating to form *collodial coacervate droplets*. Both the structures had a membranous outer covering. These early cell-like structures were called *eobionts*.

Though chemically different, these eobionts exhibited a capacity for growth at the expense of the surrounding liquid medium. These eobionts evolved into the first cells.

ORIGIN OF PROKARYOTIC AND EUKARYOTIC CELLS

Fossil records show that prokaryotic cells (bacteria and blue green algae) appeared on earth prior to eukaryotic (algae) cells.

PHENOMENON OF DESCENT WITH CHANGE

Among organisms that reproduce sexually no two individuals are exactly alike. The individuals of every species vary in size, proportion, colouration, external and internal structure, physiology, biochemistry and habits. The differences among individuals of a species are called *variations*.

Variations occur in the gametes (germinal cells) and are inherited by the next generation. Depending upon their utility, the variations are classified as *useful, harmful* and *neutral*. The surviving individuals inherit and possess only the variations. These variations are thus transferred to the next generation. The surviving individuals of this generation contain an *improved version* of the useful variations. In this way, the good variations get continuously improved under a particular environment. This phenomenon is called *continuous selection*.

Continuous selection increases the number and quality of the favoured variations. They ultimately collect in such large numbers that they form a completely *new species*. Further change in the environment will cause selection of new types of variations suitable to that climate. In this way different types of species are continuously being formed on this earth.

Activity 5: *Obtain eight sea shells. Select two variable factors such as size, colour, etc. Prepare a simple graph to indicate the relationship between these characteristics.*

PERPETUATION THROUGH INHERITANCE AND ISOLATION

Isolation is one of the important factors in organic evolution. According to Metcalf, anything which divides a species into groups, which do not freely interbreed, is said to *segregate* (isolate) the members of the species. Heredity, variation and isolation rank together as equals on which the whole theory of organic evolution depends. In the broadest sense, any factor may be said to play an isolating role if it interferes with free interbreeding among all the members of the species.

Some of the important isolating agents are:

1. Geographic isolation: This exists when two populations are separated by some geographic barrier, this may result in the formation of distinct geographical races.

2. Isolation due to distance : If a species lives over a wide extent of territory which is unbroken by barriers, there may be isolation from other similar species.

3. Environmental isolation: Species which are environmentally isolated live under different conditions at least during the breeding season. For instance a fish-eating and a seed-eating bird are environmentally isolated even though they live in the same locality.

4. Climatic isolation: There are often abrupt climatic differences within range of a particular species which may call for different adaptive changes and thus produce different races and varieties.

5. Reproductive isolation : Some species are kept from mating by psychological differences. The courtship behaviour of animals is designed not to influence choice of mates but to arouse readiness for mating. Even after mating, there are sometimes physiological obstacles which prevent the union of gametes.

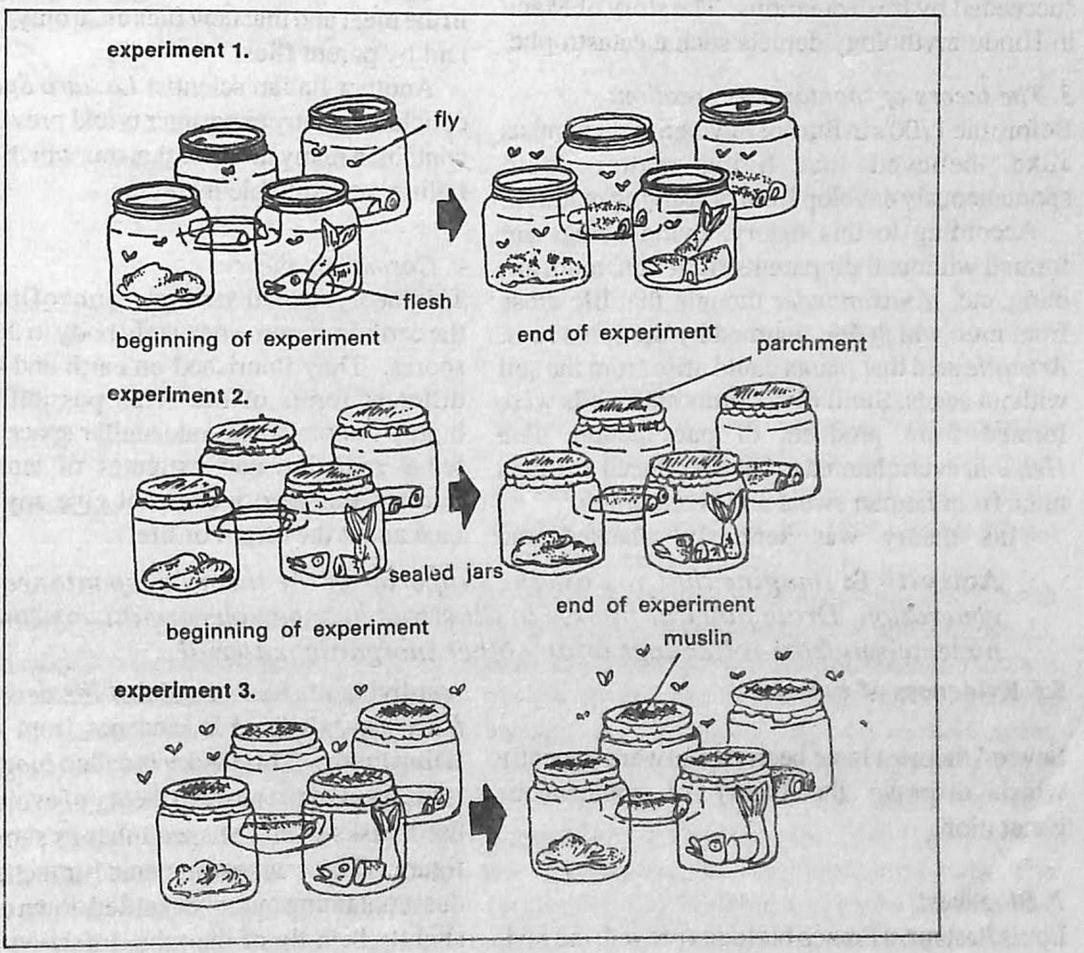

Fig. 5.9 Redi's experiment

THEORIES OF ORIGIN OF LIFE

The different classical and modern theories of the origin of life can be briefly considered as follows:

1.The special creation theory:

According to this theory, God created life. The Book of Genesis in the Bible records that God created life in six days. Hindu mythology has similar beliefs.

2. The theory of catastrophism:

The theory of catastrophism was proposed by *Cuvier*. He suggested that there were periodic world-wide cataclysms during which all living forms were destroyed and that these were succeeded by fresh creations. The story of Manu in Hindu mythology depicts such a catastrophe.

3. The theory of spontaneous creation:

Before the 1700's in Europe, laymen and scientists alike, believed that living matter could spontaneously develop from non-living material.

According to this theory, living beings are formed without their parents from rain, mud, air, dung, etc. *Anaximander* thought that life arose from mud which was warmed by the sun's rays. *Aristotle* said that plants could arise from the soil without seeds. Similarly, worms and snails were formed from products of putrefaction. *Van Helmont* even claimed to have produced artificial mice from human sweat and wheat grain.

This theory was seriously attacked and ridiculed by *Redi* and *Spellanzani*. Francisco Redi, an Italian physician tested the idea of spontaneous generation of life and in 1668 published the results of his experiments.

He took the flesh of four kinds of animals and cooked it, so that nothing could have remained alive in it. Then he placed some of each type in three jars. One he left uncovered, the second he covered with parchment and the third with fine muslin. In a few days maggots (larvae of the fly) appeared in the meat. Redi observed how the flies laid their eggs on the muslin, but only when these eggs fell on the meat did maggots developed inside it.

From this experiment, he concluded that the maggots or larvae do not generate spontaneously in the meat and that new flies arise only from eggs laid by parent flies.

Another Italian scientist *Lazzaro Spellanzani* concluded many experiments and proved that air contained many microorganisms which thrive on falling on a suitable medium.

4. Cosmozoic theory:

This theory states that simple forms of life reached the earth from some heavenly body in the form of spores. They flourished on earth and produced different forms of life. This possibility seems highly remote since interstellar space is full of lethal radiation and extremes of temperature. Further, this theory does not give any concrete clue about the origin of life.

Activity 6: *Imagine that you are the supporter of the theory of spontaneous generation. Draw fanciful figures to illustrate how various organisms could have arisen from rotten logs or any other inorganic material.*

5.5 Evidences of evolution

Several theories have been put forward recently which disprove the theory of spontaneous generation.

1. Biogenesis:

Louis Pasteur, a French biologist proved, in 1864, that even microorganisms do not originate from non-living organisms and that *life develops only from pre-existing* life, and not from any non-living things. This theory is called *biogensis* and is the basis of the modern theory of evolution. He used flasks with S-shaped tubes as shown in the figure. These tubes prevented infection as the dust containing microbes settled down only at the slightly bent tip of the tube. Infection appeared immediately when the neck was broken.

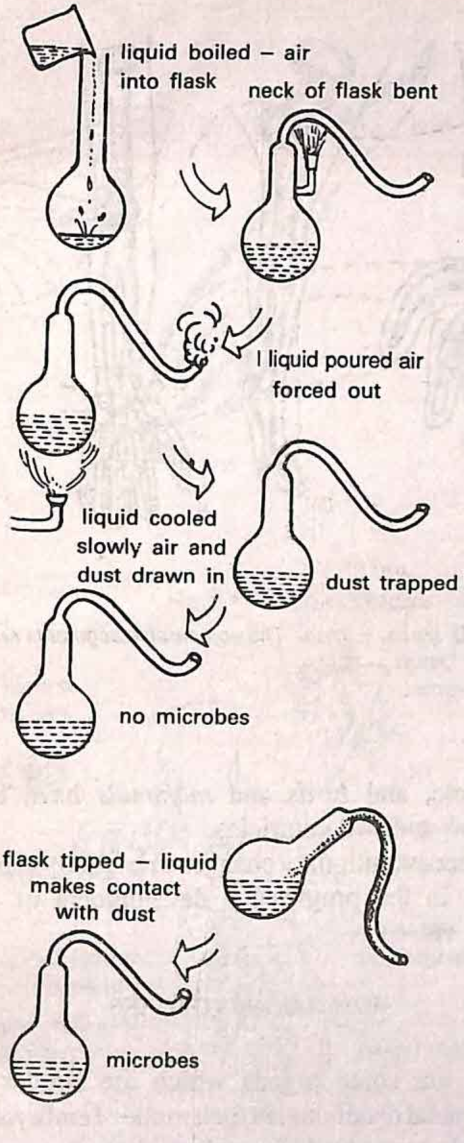

Fig. 5.10 Pasteur's experiment

2. Abiogenesis (chemical evolution)

In 1924, a Russian biochemist, Alexander Oparin, published a theory which suggested that organisms have evolved from inorganic chemicals present on the primitive earth by a process called *abogenesis* (new term for spontaneous generation). Oparin's hypothesis attempted to show how organic molecules could have been originally formed and grouped together to form primitive cells, the *coacervates*.

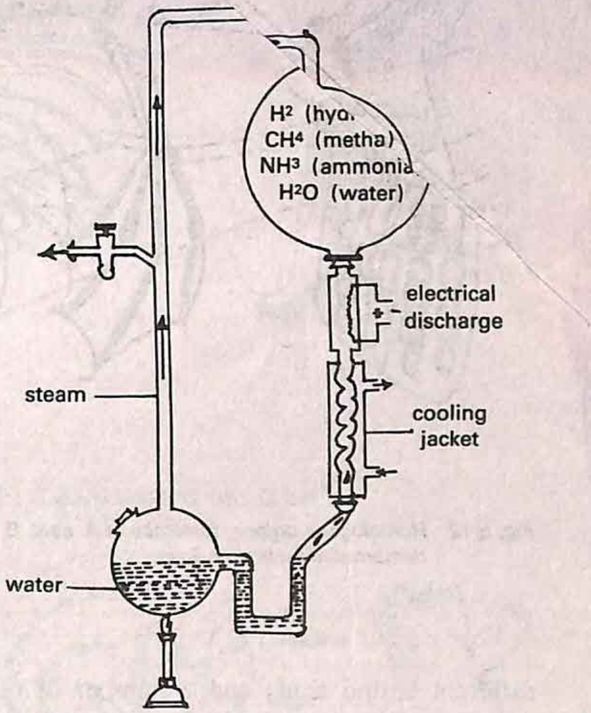

Fig. 5.11 Miller's experiment

3. Uray-Miller's experiment

It was only in 1953 that experimental support for Oparin's theory was forthcoming in the form of a classic experiment by *Stanley Miller*, a graduate student working under the sponsorship of the eminent chemist, Harold Uray.

Miller recreated the atmosphere of early earth by circulating a mixture of hydrogen, ammonia, methane and water vapour in a vessel. He then passed an electric spark through the gaseous mixture for a week. By the electric spark discharge, he intended to recreate lightning. After a week, Miller analysed the water that had accumulated in the condenser of the apparatus to see if it contained any organic compounds. The results were astounding and more than he had expected. It was found that many compounds had been created, including urea, lactic acid, four

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1.The special c
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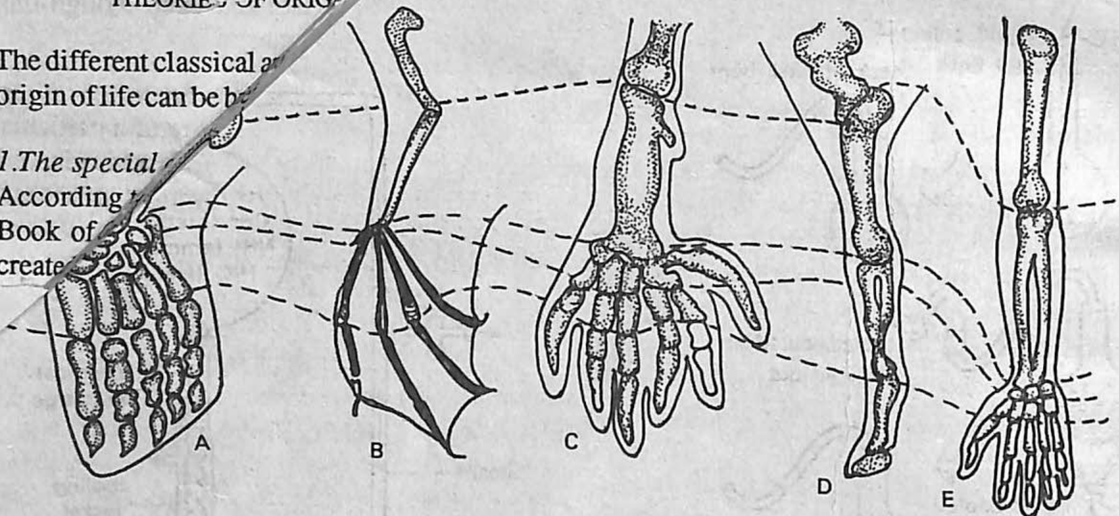


Fig. 5.12 Homologous organs; forelimbs of A. seal, B. bat, C. mole, D. horse, E. man. The comparable segments are demarcated by broken lines.

different amino acids and a number of other substances important in the chemistry of living things. The presence of amino acids was particularly significant, for amino acids are the building blocks of which proteins, the basic molecules of life are composed.

Some of the evidences that indicate the occurence of organic evolution are as follows

5.6 Evidence from comparative anatomy

There are evidences of evolution in certain anatomical features of vertebrates. It has been found that a progressive evolutionary change in the anatomy of the *heart* in the various classes of vertebrates has taken place. *Fishes* have a simple heart with one auricle and one ventricle, *amphibians* have two auricles and one ventricle *reptiles* have two auricles and a partially divided ventricle, and *birds* and *mammals* have two auricles and two ventricles.

Other evolutionary changes in anatomy can be traced in the progressive development of the *brain*, etc.

HOMOLOGOUS ORGANS

There are some organs which are similar in anatomical details and in their mode of embryonic origin but may be different in their performance. Such structures are called *homologous organs*.

Thus, the arm of a man, the wing of a bird, the wing of a bat, the flipper of a seal, etc., have the same type of skeleton although they perform different types of locomotion. The presence of such homologous structures can be beautifully explained by the theory of organic evolution.

Activity 7: *Observe some of the homologous and analogous organs in your school or city museum. What is their significance? Write a brief note on it.*

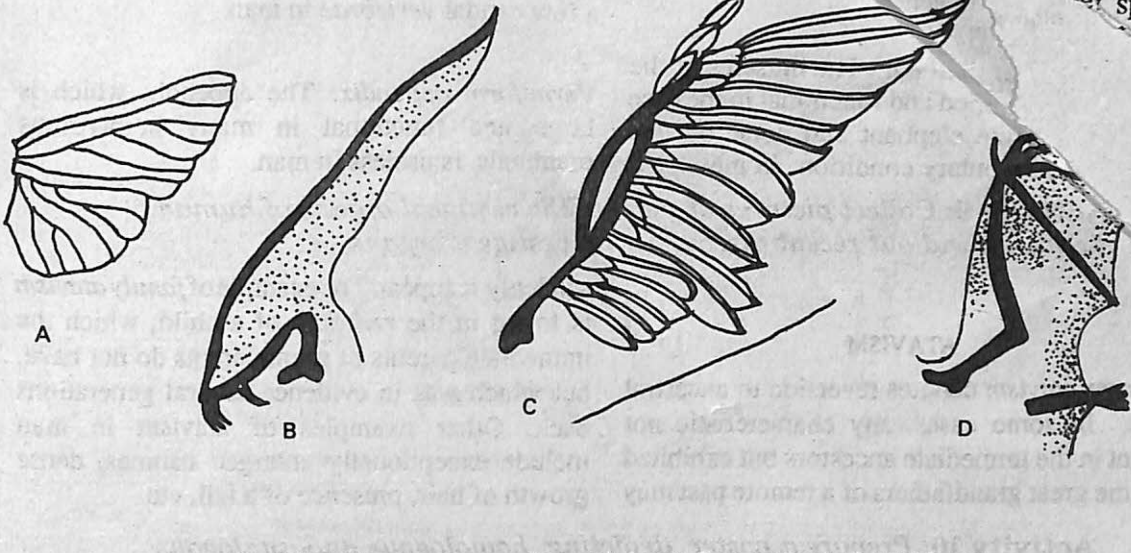


Fig. 5.13 Analogous organs - wings of A. insect, B. pterodactyl, C. bird, D. bat.

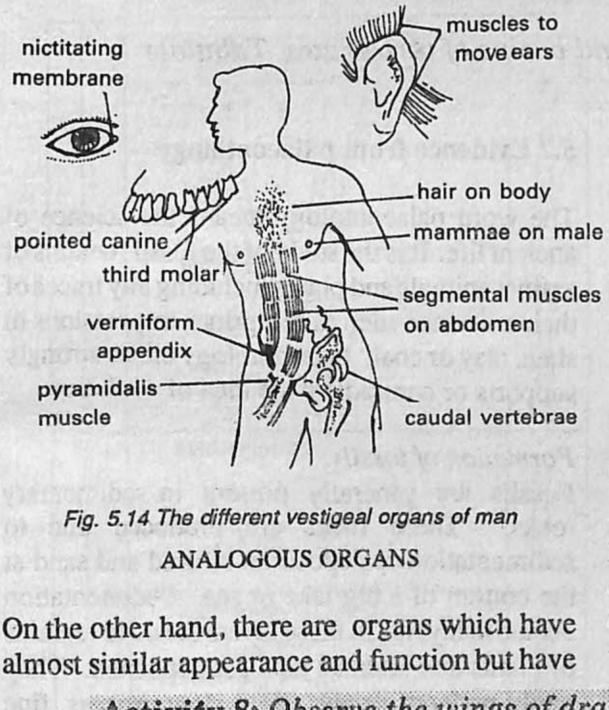


Fig. 5.14 The different vestigeal organs of man

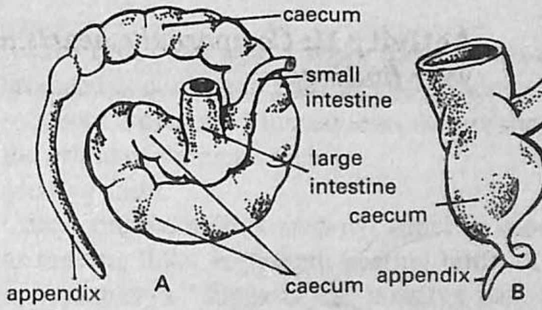


Fig. 5.15 Caecum and vermiform appendix in A. rabbit, B. man.

ANALOGOUS ORGANS

On the other hand, there are organs which have almost similar appearance and function but have a different structural pattern and origin in different groups of animals. For instance, the wings of an insect are similar to those of the bird, pterodactyl (an extinct-flying reptile) and bat, since they have the same function but their structure and origin are different. Apart from this, there is no close relationship between insects and the vertebrates mentioned.

Activity 8: *Observe the wings of dragonfly. Compare it to that of a bat. List their differences.*

VESTIGEAL ORGANS

Throughout the animal kingdom we come across useless organs; which are greatly reduced, while in other allied forms they may be large and functional. It can be said, that due to the changed conditions of life, an organ previously functional and useful becomes useless and so begins to ve generations. A few of the

re:

ternal ear: The muscles of the loped and functional in the case like elephant and horse but are rudimentary condition, in man.

Tail: The tail of anthropoid apes is represented by a few caudal *vertebrae* in man.

Vermiform appendix: The appendix which is large and functional in many herbivorous mammals, is useless in man.

Activity 9: *Collect pictures of some of the vestigeal organs of human beings. Find out recent discoveries on vestigeal organs.*

ATAVISM

The term *atavism* denotes reversion to ancestral types. In some cases, any characteristic not present in the immediate ancestors but exhibited by some great grandfathers of a remote past may suddenly reappear. The example of *family atavism* is found in the *red hair* of a child, which the immediate parents or grandparents do not have, but which was in evidence several generations back. Other examples of atavism in man include exceptionally enlarged canines, dense growth of hair, presence of a tail, etc.

Activity 10: *Prepare a poster depicting homologous and analogous organs, vestigeal organs and atavism in human beings.*

Activity 11: *Compare the hearts and brains of vertebrates. Tabulate your findings.*

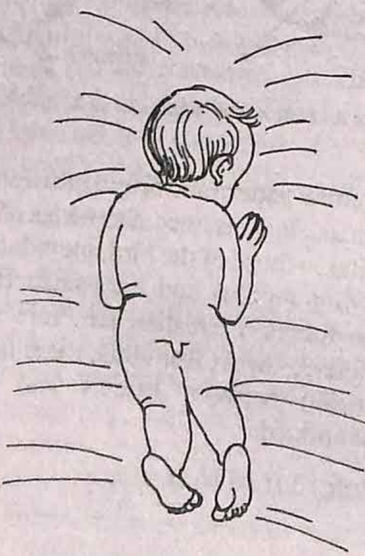


Fig. 5.16 A newly born baby showing tail (atavism)

5.7 Evidence from palaeontology

The word palaeontology means the science of ancient life. It is the study of the fossil remains of extinct animals and plants including any traces of their existence such as footprints, impressions in slate, clay or coal. Palaeontology either strongly supports or contradicts the idea of evolution.

Formation of fossils:

Fossils are generally present in sedimentary rocks. These rocks are produced due to sedimentation or deposition of mud and sand at the bottom of a big lake or sea. Sedimentation occurs in layers. In these layers the dead remains of plants and animals also get deposited. They partly undergo decay. By a slow process, fine mineral particles penetrate the dead cells, tissues and organs.

Distribution of fossils:

Different types of fossils are distributed in the

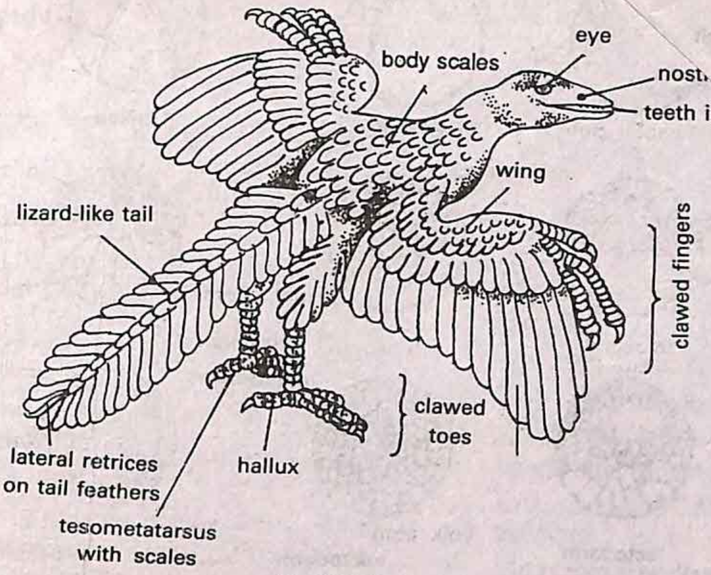


Fig. 5.17 Archaeopteryx.

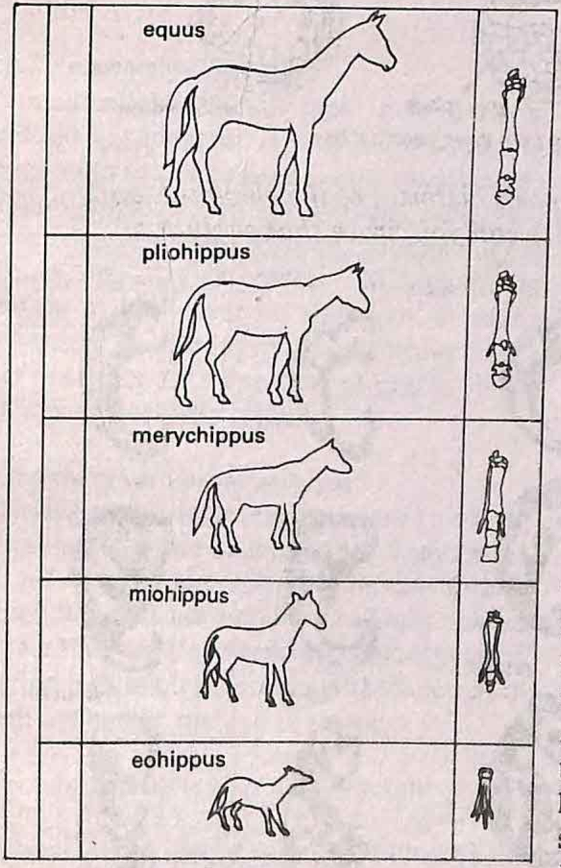


Fig. 5.18 Evolution of horse

rocks of different ages. When these fossils are arranged according to their age of formation, a sequence is evident. This sequence clearly shows the origin of various species.

Missing links:

Connecting links which are now extinct are known as missing links, e.g., teeth bearing birds. The *archaeopteryx* suggests the possible path by which some of the reptiles got transformed into birds. It could fly like a bird and had wings and feathers. However, it possessed several reptilian characteristics, too, like a long tail, teeth, claws on free fingers, etc.

FOSSIL HISTORY OF THE HORSE

The present day horse (Equus) arose about 60 million years back. At that time, the animal was the size of fox or cat, *(Eohippus)*. It possessed four anterior and three posterior functional toes. About 40 million years back, Eohippus changed to another animal named *Miohippus*. Miohippus had only three functional toes on all its limbs. Its size was equal to the modern goat. After about 10 million years, Miohippus changed into

Th

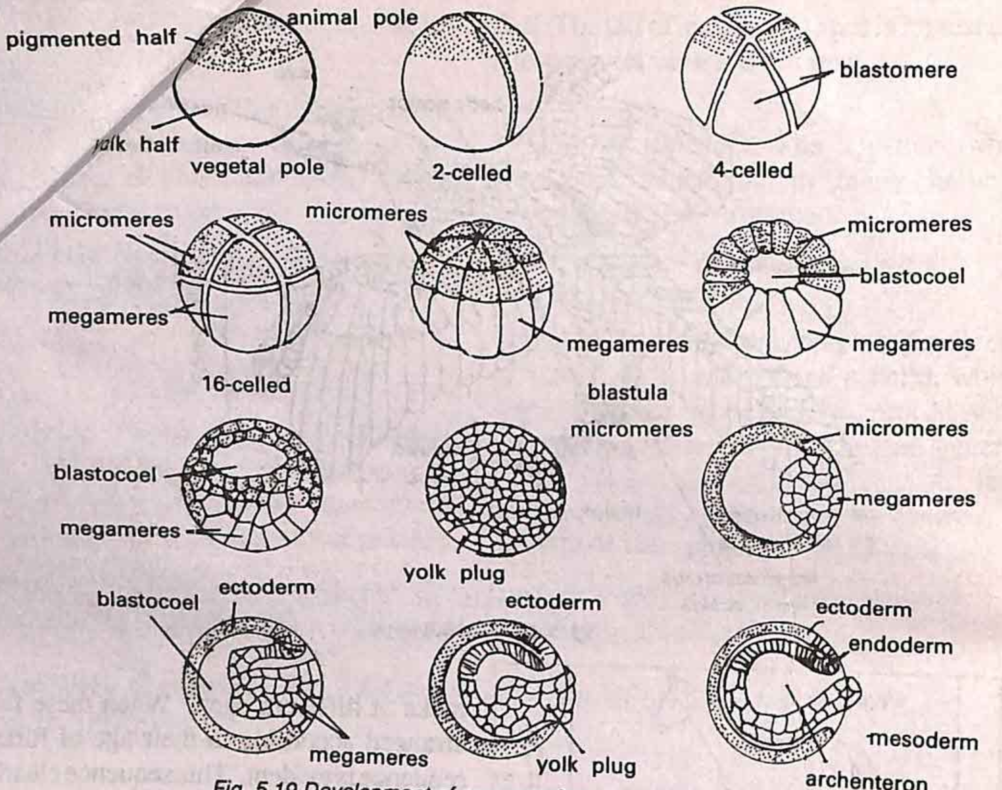


Fig. 5.19 Development of egg upto three germinal layers

Activity 12: *In groups find out the fossil histories of the elephant, and camel. By tracing their fossil histories can you prove that evolution must have taken place?*

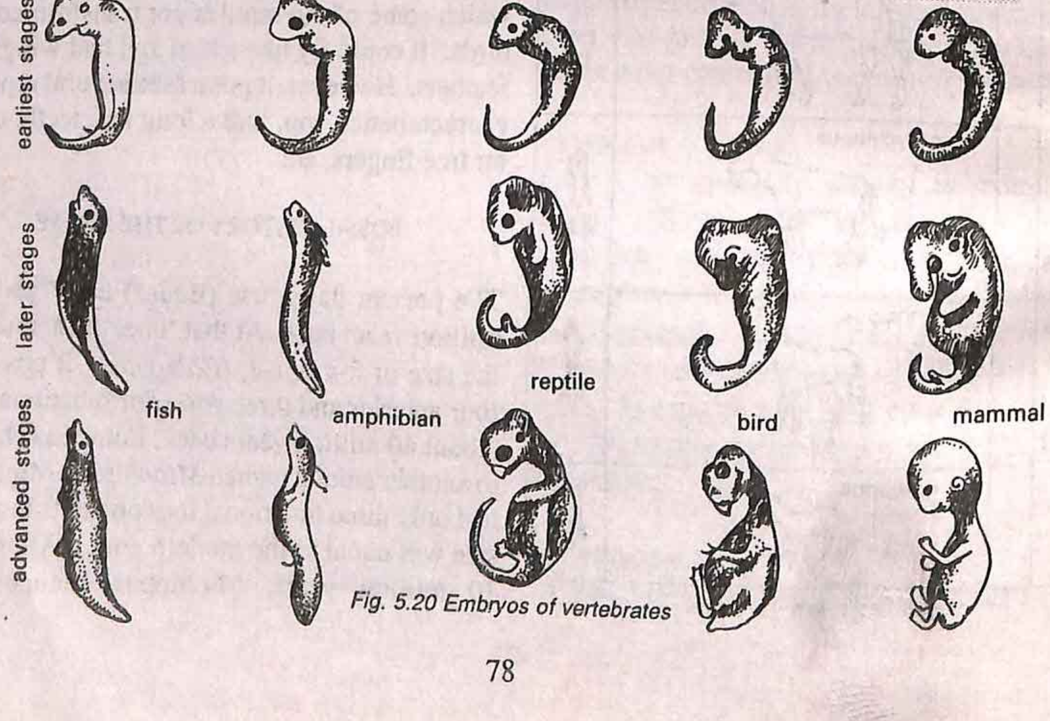


Fig. 5.20 Embryos of vertebrates

Merychippus. This animal resembled a modern ass. It had only one functional toe. Two smaller toes hung on the two sides. The teeth had short roots. They developed foldings of enamel. These teeth were helpfu[illegible] grazing on grass. The [illegible] such a large horse arose from th[illegible] species. [illegible] animal only about [illegible] thousand years back. [illegible] non-functional toes [illegible]use have become reduced to sp[illegible]t bones.

Activity 13: *Collect pictures of extinct reptiles. Write a short not[illegible] on each.*

5.7 Evidences from embryology

A study of comparative embryology provides further evidence for evolution. A very young human embryo looks very similar to the very young embryos of other mammals, birds and reptiles. At certain stages in their development all these embryos have fish-like characteristics with gill slits in the pharynx and a vascular system with a single circulation system. From these and other characteristics it is possible to infer that land vertebrates probably had aquatic ancestors.

Similar early development:
All multicellular animals grow from a single fertilised egg or zygote. The zygote produces, at first, a solid ball of cells or *morula*, followed by a hollow single layered ball or *blastula* and a two layered structure called *gastrula*. The diploblastic animals stop further growth. In triploblastic animals, a third layer or *mesoderm* is added between the first two layers. These three germinal layers produce the same type of organs in the different triploblastic animals.

Similarity in vertebrate embryos:
In the early stages of development, the vertebrate embryo are fish-like in appearance. They have a *tail*, *gill-slits* and a *notochord*. The resemblance continues for longer periods in closely related animals. For instance, even an expert embryologist will find it difficult to distinguish between an 8-month old human foetus and an ape.

BIOGENETIC LAW — VON BAER

A German embryologist, *von Baer* (1792-1876) tried to deduce some evolutionary meaning from the embryology of different animals. His *basic principles of embryology* state that.

1. general characteristics appear before special characteristics,
2. from these less general develop and finally the special characteristics develop,
3. an animal during development departs progressively from the forms of other animals,
4. the young stages, of an animal are like the young or embryonic stages of other animals, lower in the scale, but not like the adults of those animals.

RECAPITULATION THEORY

Another German biologist Haeckel (1834-1919) forwarded the *theory of recapitulation* or *biogenetic law* which stages that the life history, of the individual *(ontogeny)* gives a brief resume of the evolutionary history of the race *(phylogeny)*; Or, more briefly, *'ontogeny repeats phylogeny'*.

5.9 Organic evolution

CHARLES DARWIN - A BIOGRAPHY

Charles Robert Darwin was born at Shrewsbury in England in 1809. His grandfather, Erasmus Darwin, was a famous poet and scientist. His father was a physician and wanted him to take up the medical profession. But Charles Darwin chose to do nothing except observe living things. In 1931, when he was 22 years old, Darwin took a journey around the world and as a consequence changed the course of human history. He joined the crew of a ship, the *Beagle*, as a naturalist, ng organisms and exploring primarily in [illegible] America. He had time and the interest to speculate on the problem of species formation. During his voyage Darwin took an important side trip to the Galapagos islands. There, relatively isolated from the continent, were an unusual group of tortoises, lizards and especially a group of birds called *finches*. On the various islands these species had specialised in diverse ways, yet they clearly were closely related to each other.

Returning to England after five years on the voyage, Darwin examined his specimens and mused on the origin of species. In 1844, he wrote a summary of his theory but did not publish it. In 1858, Darwin received a letter and a paper from an entomologist, Alfred Russel Wallace, who had spent several years in East Indies and had developed ideas similar to Darwin's. Darwin's first impulse was to withdraw his theory in favour of Wallace's, but some of his friends, like geologist Charles Lyell and botanist Joseph Hooker persuaded him to prepare a note on his conclusions. So, Darwin read his brief note together with Wallace's essay at the meeting of the Linnaean society of London on July 1, 1858.

Finally, Darwin had put together his monumental work in the book '*On the origin of species by means of natural selection*'. But at that time, the fact that humans were considered animals that had evolved from a lower species did not convince the general public.

THE MAIN FEATURES OF DARWINISM

Natural selection is the main theory given by Charles Darwin. This seems to be the most important factor in organic evolution and has been defined as *the survival of the most fit with the inheritance of the species* — forming adaptations wherein fitness lies.

Prodigality of production: All animals and plants tend to multiply at least in geometrical ratio, whatever may be the method of reproduction.

An oyster can give rise to 60 million offspring in one generation. In five generations, the volume of oysters will be eight times the volume of the earth.

Similarly, the elephant is the slowest breeder among mammals but a single pair could produce an average of six young ones and would have in 750 years about 19 million descendents.

The earth cannot support increased numbers of any organism because it has limited food, space and others requirements for life.

Struggle for existence: The struggle for existence is the competition between all organisms and between each individual and the physical environment.

Intraspecific struggle: This is the struggle against the organisms own kind. In artificial lobster culture, if the newly hatched ones are not immediately transferred, they turn into their own worst enemies and the result is *cannibalistic selection*, i.e., the stronger ones consume the weaker ones.

Interspecific struggle: This takes place between members of different species, often competitively, but more often because one may afford food for the other.

Environmental struggle: This is the struggle against the physical environment, i.e., against excess of moisture, drought, extreme heat or cold, lightning, tempests, earthquakes and volcanic eruptions.

Natural selection or survival of the fittest: In the struggle for existence, only those individuals survive which have useful variations. In other words, nature selects only those which are best fitted to struggle.

Inheritance of useful variations: The surviving individuals possess useful variations. These variations are transferred to the next generation.

The useful variations alone get continuously improved under a particular environment. The phenomenon is also known as *continuous selection.*

Formation of a new species: Continuous selection increases the number and quality of the favoured variations. They ultimately collect in such a large number and form a completely new species. Another change in the environment will cause selection of new type of variations which are suitable to that climate. In this way different species are being formed on this earth.

Activity 14: *Give a micro-lecture on Darwin's visit to Cocos and Galapagos islands. Draw diagrams of a few species of finches and write about their special adaptations.*

5.10 Heredity and variation

HEREDITY

Of all the billions of people on earth, no two look exactly alike with perhaps the exception of identical twins. Facial characteristics, hair, eye, finger prints, skin colour, hair texture, and body build make us distinct from one another. In addition to the hundreds of combinations of differentiating characteristics that are visible there are many more that are invisible. Blood chemistry, mental and physical aptitude, susceptibility to certain diseases, and other traits all contribute to our individuality. The characteristics which provide individuality to each member of a species are said to cause *variations* among individuals of a group.

Beside variations among individuals of a species there is also a similarity among them. A man, for instance, cannot be mistaken for a dog. Further, the offspring of human beings for instance, will always be human babies never puppies or kittens. This fact paved the way for the formulation of the following biological phrase: "like tends to beget like". Parents transmit their characteristics to their offspring and thus maintain the continuity of their race in the evolutionary process. The process of transmission of characteristics from one generation to another is known as *inheritance* or *heredity.*

Scientists now know that the same basic unit that produces in us the identifying characteristics of our species is also responsible for our individual differences. The person who first made decisive experiments in heredity and who formulated the basic laws of inheritance was *Gregor Johann Mendel,* a monk in the Augustinian monastery at Brunn, Austria. Mendel carried out experiments on the garden pea plant, *(Pisum sativum).* Mendel chose garden peas for his experiments because, it could be grown easily and crossed readily with well-defined characteristics.

As a result of his experiments, Mendel came to certain conclusions which are referred to as the principles of Mendelian inheritance or Mendel's law of heredity.

The law of heredity states that it is the *tendency of the offspring to possess characteristics similar to either or both of its parents.* Because of heredity, individuals, related by descent resemble one another. *The law of variation* states that there is a *tendency for their offspring to be different from their ancestors and from one another.* It is because of variation that differences exist between members of the same family and individuals of the same species. These similarities and differences can be transmitted from one generation to another.

Activity 15: *Collect pictures of human beings belonging to different parts of the world. List their characteristics highlighting variations.*

7

Activity 16: *Prepare a list of the features inherited from your father and mother by you and your brothers and sisters.*

5.11 Types of variations

The major groups of variations are as follows:

1. SOMATIC AND GERMINAL VARIATIONS

Somatic variations are acquired modifications which are forced on the organism during its life time and are caused due to extrinsic (external) influence, e.g., absence of a digit in man.

Environmental factors may induce somatic variations. For example, the growth and development of several plants and animals vary with the temperature and light, the nutrients it lives on, as well as the attack of disease germs, pests or parasites. Differences in the production or action of hormones can bring about variations in the development and differentiation among individuals. Human beings living at very high altitudes (where oxygen in the air is low) produce a higher number of red blood cells in their blood.

Germinal variations arising in the germplasm are, due to either recombinations which originate due to new groupings of the genes or due to mutation caused by radical alterations in the chemical composition.

Characteristics which appear visibly in an organism during its lifetime are called *phenotype,* while those characteristics which are present genetically (i.e., in the form of genes) whether they are visible or not are collectively called the *genotype* of the organism.

Variations do not depend on external conditions for their origin. External conditions may hamper or arrest their development but cannot cause them.

In the bee *(Apis),* the sex distinction between the workers and queens is a somatic variation while that between drone and queen or workers is germinal. The unfertilised eggs produces drones or male bees, while the fertilised eggs produce potential females. Among the fertilised eggs a vast majority of them feed on a meagre and non-nutritious diet and develop into workers which are undeveloped females. A select few are fed on highly nutritious "royal jelly" and develop into mature females or queens. This variation is an acquired one.

2. DETERMINATE AND INDETERMINATE VARIATIONS

Indeterminate variations are not subjected to any law but may occur in any direction. The Darwinian factor of natural selection operates on indeterminate variations. Determinate variations are controlled by some unknown influence and are confined to certain definite lines or directions of change, usually to adapt to the organism's surrounding. However its existence is generally doubted.

3. CONTINUOUS AND DISCONTINUOUS VARIATIONS

Continuous variations are said to occur abundantly in a graded series. These are small, so called *Darwinian variations* , which are to be acted upon by natural selection. The change in each generation is very slight. These fluctuating variations are now found to be non-inheritable and thus have no place in evolution.

Discontinuous variations are mostly large, and have also been called *sports,* or *saltations* or *mutations*. They are supposed to produce sudden and large changes in one single generation.

CAUSES OF VARIATIONS

In *somatic variations,* the modifications are produced in response to any external condition. The influence of abundance or scarcity of food, heat, cold or any other environmental factor is felt by the individuals in greater or lesser degree. However, the modifications are not important for evolution.

The *germinal variations* are mainly concerned with evolution. Changes taking place in the germplasm of an organism are transmitted through the gametes to the offspring, and may be inherited by the progeny. These are called *germinal variations*. Most of these are rather small and continuous, i.e., they continue to occur as light differences in size, colour or shape among the members of a species for a number of successive generations.

Some basic concepts

1. DNA and RNA are present in the chromosomes. These control all the activities and characteristics of the cell.
2. There are various theories about the origin of life on earth - special creation, spontaneous generation, cosmozoic theory, etc.
3. Experiments done by Pasteur, Miller and Oparin support the theory of evolution.
4. The progressive complexity of brain and heart of vertebrates, homologous, analogous, vestigial organs, etc. prove that evolution must have taken place.
5. Evidences from the study of palaeontology, embryology, fossils, etc. show how evolution must have taken place.
6. Darwin's theory of organic evolution suggests that variations have taken place because of natural selection, survival of the fittest, environmental changes, etc.

Some suggested projects / activites

1. *Examine whole mounts or slides of the various developmental stages of chick. Compare any late stage to a placental mammal.*
2. *Prepare posters to illustrate Darwin's concepts of organic evolution.*
3. *Collect pictures of various scientists concerned with evolution (Darwin, Pasteur, Stanley Miller, Lamarck, Hugo De'Vries) and write a short note on their contributions.*
4. *Observe the preserved specimens of various embryos, i.e., fish to man and write your own comments on each.*
5. *See a film on Natural Selection. Discussion the significance of variation, adaptation and natural selection in the process of evolution.*

REVISION

Answer the following questions.

1. Define the term fertilisation.
2. What is reproduction? What is its significance?
3. Where are genes located?

4. What provides the molecular structure of DNA?
5. What are the different types of RNA?
6. Describe the structure of RNA.
7. What is the possible age of Earth?
8. What is an eobiont?
9. Define organic evolution in the minimum possible words.
10. Name three vestigeal organs of man.
11. Which part of man is homologous to the wings of a bird or bat?
12. What was the significance of Miller's experiment?
13. How were fossils formed? How is the age of a fossil determined?
14. How does comparative embryology support organic evolution?
15. Why is the Natural selection theory called Darwinism?
16. Tabulate the differences between DNA and RNA.
17. List the factors that cause germinal variations in an organism.
18. What is the significance of somatic variations?
19. What are the efforts necessary to ensure the survival of man?
20. Describe the stages of evolution of horse.

II *Choose the best answer.*

1. Darwin's theory of natural selection:
   a. was the first theory of evolution.
   b. has been replaced completely.
   c. failed to explain the source of variation in organisms.
   d. did not account for fossils.
2. Who proposed the *Biogenetic law?*
   a. Lamarck. b. Aristotle. c. Ernst Haeckel. d. Harvey.
3. Hugo De'Vries is famous for:
   a. not accepting Darwinism in toto
   b. being a brilliant botanist.
   c. the theory of mutation.
   d. studying every theory critically.
4. The modern horse Equus developed from the earliest ancestor.
   a. Mesohipus. b. Eohippus. c. Merychippus. d. Miohippus.

5. Darwin was a greatly infuenced during his formation of the theory of Natural Selection by
   a. De'Vries theory of mutation.
   b. Malthus' essay on population.
   c. Mendel's experiment on peas.
   d. Lamarck's idea on the inheritance of acquired characters.

6. The slow process by which organisms arise form pre-existing forms by genetic variations is called
   a. hybridization. b. mutation. c. evolution. d. genetics.

7. Organic evolution would not nave taken place if
   a. individuals in a population did not show gene variations.
   b. individuals did not transmit the characteristics acquired to their offspring.
   c. somatic variations did not get transformed into genetic variations.
   d. somatic variations did not get inherited.

8. Every organism in its development repeats its evolutionary history. This is called
   a. Lamarck's theory of acquired characters.
   b. Haeckel's recapitulation theory.
   c. Natural Selection theory of Darwin.
   d. Beadle and Tautum theory.

III *Differentiate between the following pairs*

1. DNA and RNA. 2. Chromosomes and genes. 3. Special creation theory and theory of catastrophism.

IV *Make true (or) false.*

1. Multicellular organisms arise from pre-existing organisms only. ☐
2. In all viruses, DNA is the hereditary material. ☐
3. The genetic code consists of two adjacent and sequential nucleotides. ☐
4. Viruses lack the capacity for self reproduction and self regulation. ☐

6. Organisms and environment

Adaptation - the outcome of prodigality of production, the stress and strain of the struggle for existence - diversification - invasion of different ecological niches of fauna and flora - types of adaptations - nutritional habits and habitats - fresh water habitat - epiphytes, parasites, symbionts and special adaptations - fossorial, aquatic, arboreal, volant, active and passive flight - social life of bees - colouration and mimicry - kinds - examples - colouration - concealing - false warning and signalling, protection, aggressive and alluring colouration with suitable examples.

There are millions of species of animals living on earth, each showing a fascinating variety of adaptations. Adaptation is the way animals behave when they feed, fight or mate. It is also the way they respond to the things which change in their environment.

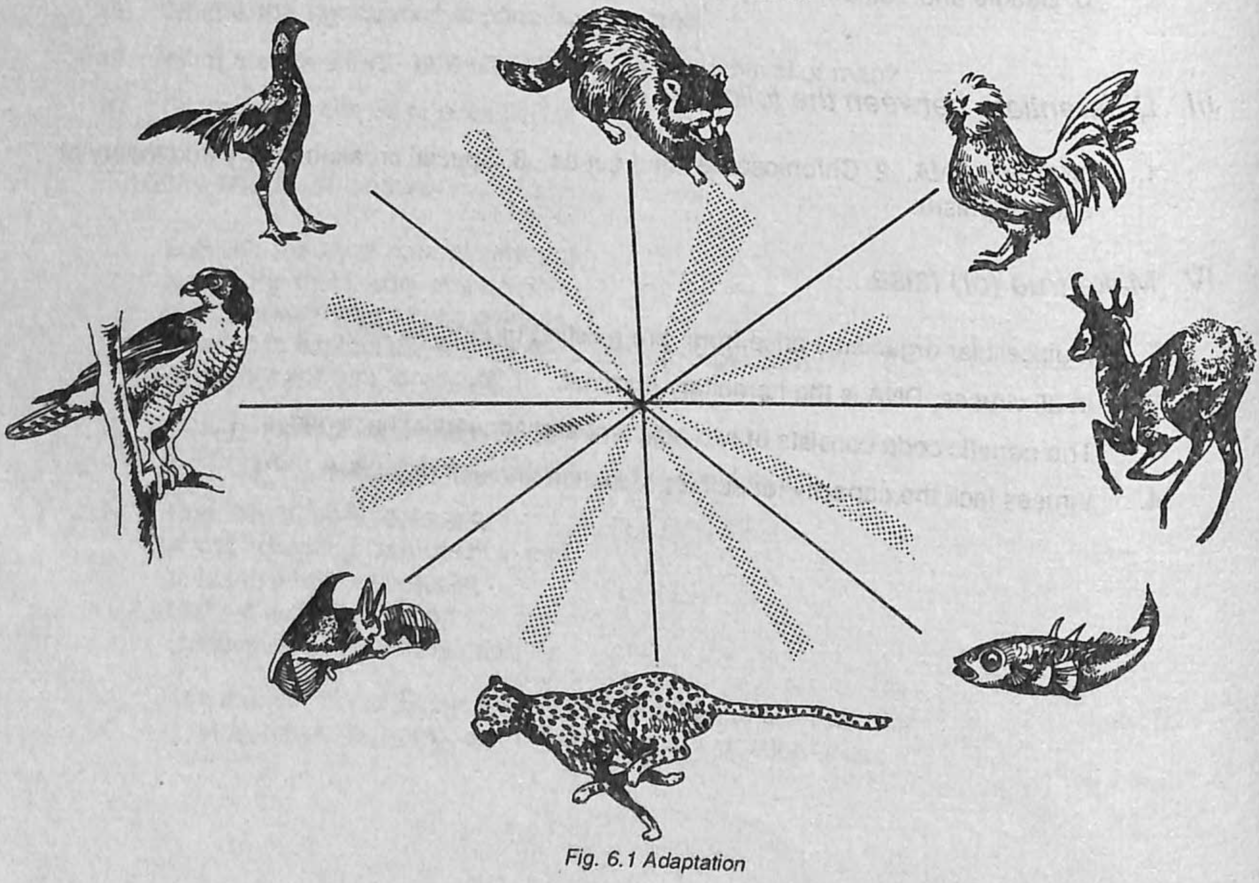


Fig. 6.1 Adaptation

6.1 Adaptation - the outcome of prodigality of production

Nature has given all living organisms the urge and the instinct to adapt themselves marvellously to the surroundings and living conditions. Therefore, variations within a species are seen all around us. The main reason for this is that every animal has to struggle for its very existence on earth. To combat this, the rate or reproduction is several times higher than the rate of survival. As each species tries to adapt itself to its surroundings, the ones who cannot do so adequately may not survive. The best adapted ones survive this critical test while the ill-adapted ones are weeded off from the earth. And, as more and more species inhabit the earth they have to spread out in different regions and adapt themselves to the conditions prevailing there.

Activity 1 : *Enumerate two useful variations and two harmful variations in human beings. Give scientific reasons for your answer.*

6.2 Diversification of flora and fauna

Once having established themselves as a race, the animals tend to invade different ecological niches (particular environment) and undergo diversification. This is known as *adaptive radiation.* Hence adaptive radiation leads to diversification of animals to suit different modes of life.

The law of adaptive radiation states *'Each isolated region, if large and varied in its topography, soil, climate and vegetation will give rise to a diversified mammalian fauna. The larger the region and the more diverse the conditions, the greater the variety of mammals which will result......'*

In recent times the law of adaptive radiation has been applied to a number of existing animal groups. A large number of instances like tunicates, teleosts, amphibians, Darwin's finches from Galapagos islands and among invertebrates annelids, insects and gastropods are known in which a population has undergone an extensive adaptive radiation by branching out to form a number of new types, each best suited for a particular environment or ecological niche.

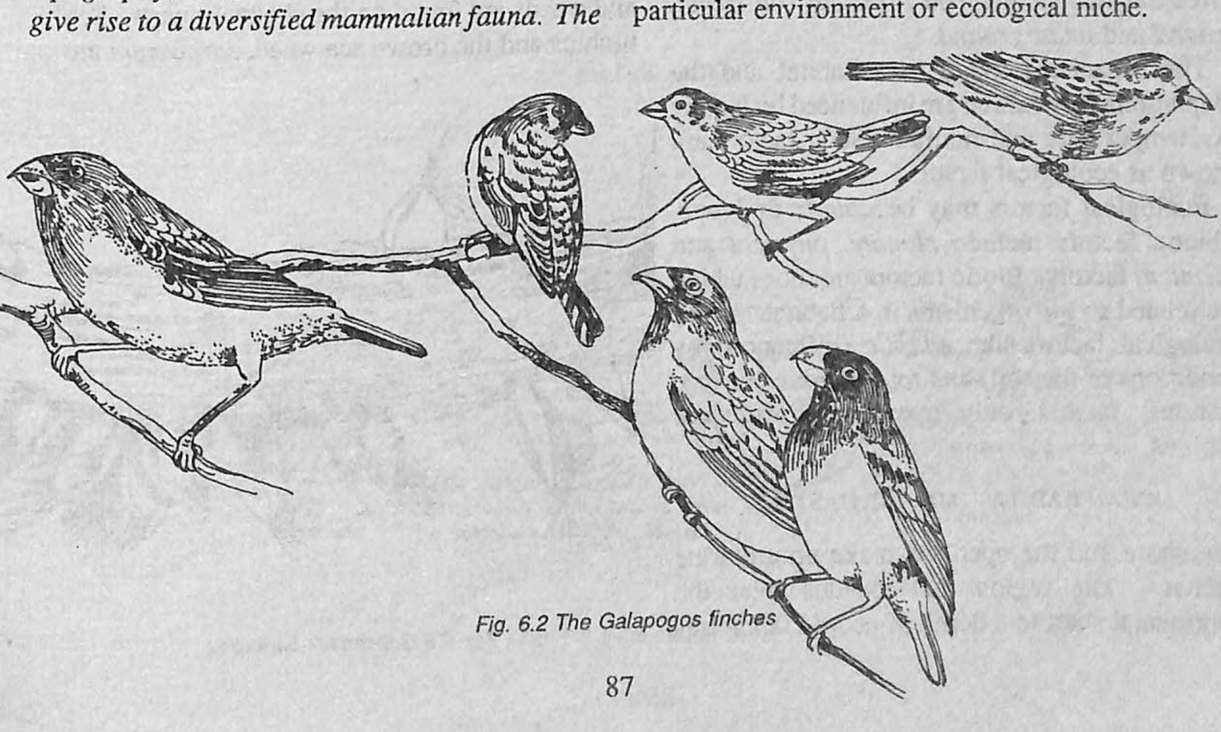


Fig. 6.2 The Galapogos finches

Activity 2: *Examine few xerophytes (opuntia), hydrophytes (lotus) and discuss their adaptive features, i.e., how their morphological and anatomical characteristics have become adapted to their surroundings*

Activity 3: *Darwin's finches (birds) are most readily distinguishable by the shapes of their beaks. Write the names of two insect - eating finches and two plant-eaters.*

6.3 Types of adaptations in animals Communities and habitats

Plants and animals live together in groups or communities. A plant community may consist of a mass of unicellular algae in a pond, a field of paddy plants or a forest of trees. Similarly, an animal community may consist of minute planktonic organisms in a pond or the animals of a particular locality such as the birds of a forest, the animals of a seashore, marine fauna and pond fauna.

The area occupied by a biotic community (living community) is known as its *habitat*. Biotic habitats can be classified as *aquatic* or *terrestrial* habitats. An aquatic habitat can be freshwater (rivers, lakes and ponds) or marine (sea). A terrestrial habitat may be *arboreal* (on trees), *ground* and *underground*.

The organisms found in a habitat and the adaptations they exhibit are influenced by factors like temperature and rainfall. Such factors are known as ecological factors.

Ecological factors may be *abiotic* or *biotic*. Abiotic factors include *climate, physical* and *chemical* factors. Biotic factors are those which are related to the organisms in a habitat. Some ecological factors like *edaptic* (influenced by conditions of the soil) and *topographic* (surface features) factors, only operate on terrestrial habitats.

OCEAN HABITAT (MARINE HABITAT)

The shore and the open sea make up a marine habitat. The region that extends over the continental shelf to a depth of about 200 metres can be divided into the *splash zone*, the *intertidal zone* and the *subtidal zone*. The splash zone is just above the high-tide mark and is moistened by the spray from breaking waves. The intertidal zone is covered with water during the high tide and exposed to air during the low tide. This zone is expose to wave action. The subtidal zone extends from the low-tide mark to a depth of about 200 metres. Beyond the continental shelf is the *bathyal zone* which extends to a depth of about 2000 metres. The *abyssal zone* extends beyond this depth to the ocean floor.

TROPICAL MARINE HABITAT

The richest flora and fauna are found on rocky shores. *Barnacles* are found on the intertidal zone of a rocky shore, while anemones, sponges and weeds are found on the sheltered parts. Sea urchins and the brown sea weed, *sargassum* are

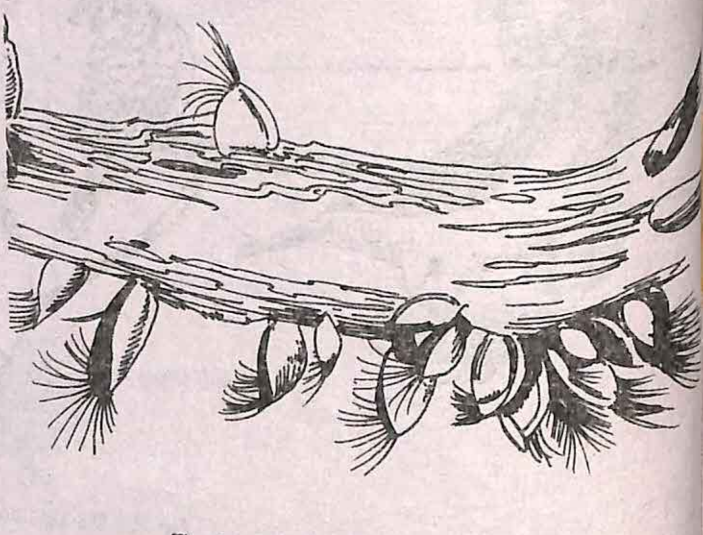


Fig. 6.3 Gooseneck barnacles

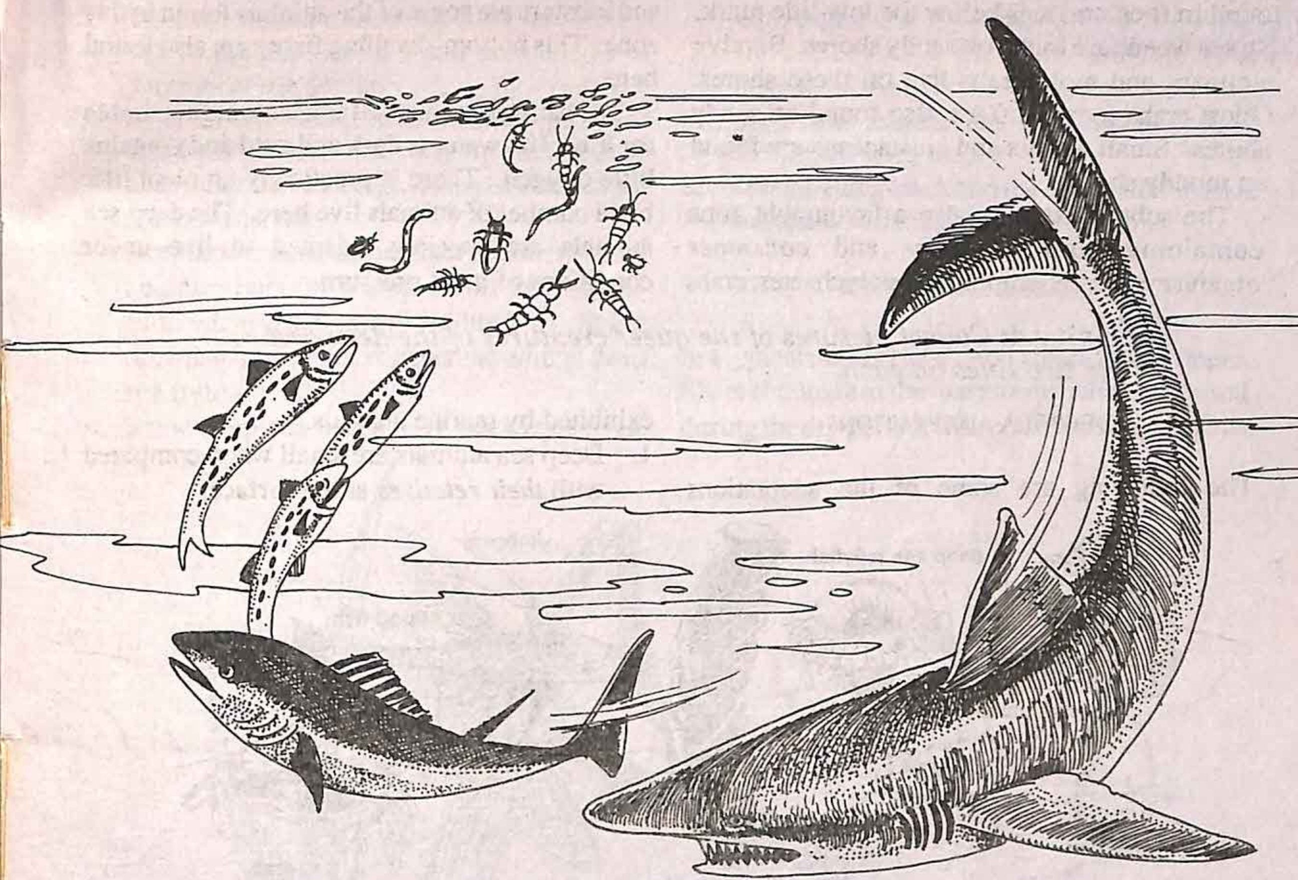


Fig. 6.4 Ocean habitat

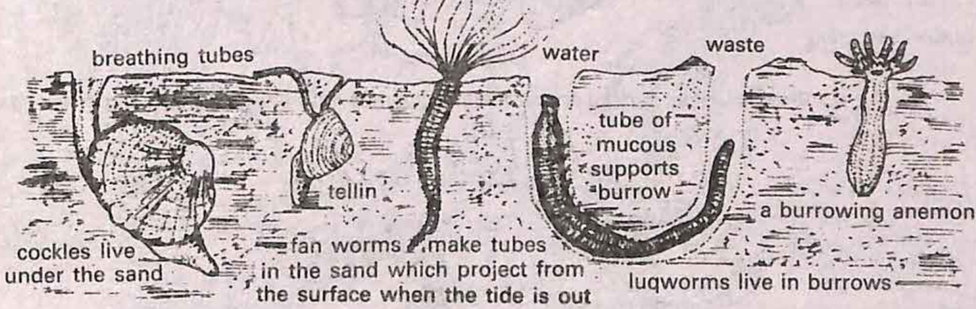

breathing tubes
water
waste
tube of mucous supports burrow
tellin
a burrowing anemone
cockles live under the sand
fan worms make tubes in the sand which project from the surface when the tide is out
luqworms live in burrows

Fig. 6.5 Sandy shore forms

found in rock crevices below the low-tide mark. No sea weeds are found on sandy shores. Bivalve molluscs and mole crabs live on these shores. Ghost crabs (ocypoda) are also found on sandy shores. Small worms and crustaceans are found on muddy shores.

The subtidal zone is also a favourable zone containing both *producer* and *consumer* organisms. Snails, amphioxus, polychaetes, crabs and lobsters are some of the animals found in this zone. This bottom-dwelling fishes are also found here.

The bathyal and abyssal zones are unfavourable for life. The water is dark and cold and contains little oxygen. There is practically no plant life, but a number of animals live here. The deep sea animals are specially adapted to live under conditions of great pressure.

Activity 4: *Collect pictures of the queer creatures of the deep ocean. Write two lines on each.*

DEEP SEA ADAPTATIONS

The following are some of the adaptations exhibited by marine animals.

1. Deep sea animals are small when compared with *their relatives* at the surface.

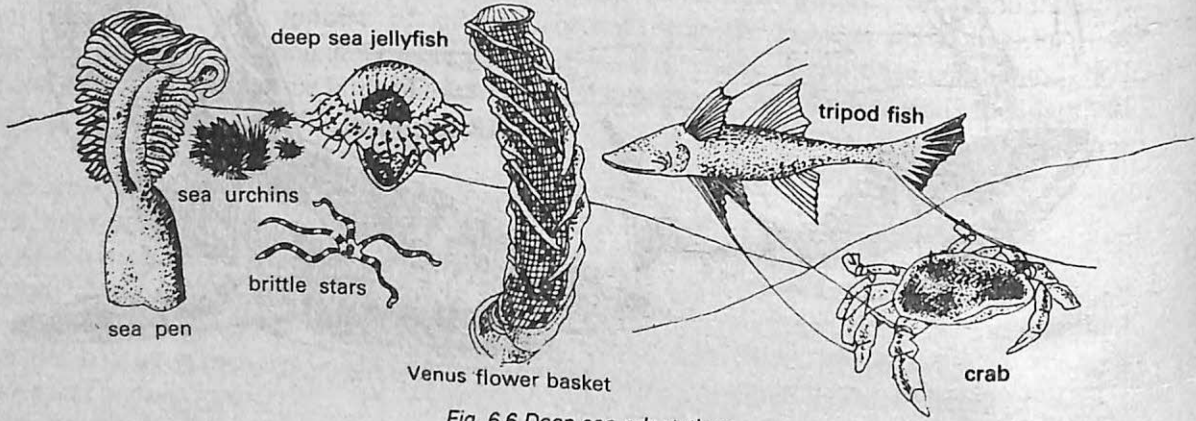


Fig. 6.6 Deep sea adaptations

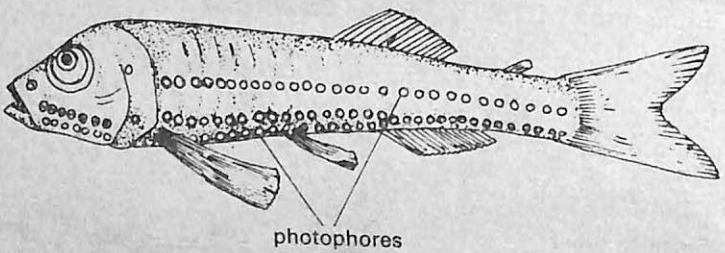


Fig. 6.7 Photoreceptors in deep sea forms (Vinciguerrias have rows of lights along their sides)

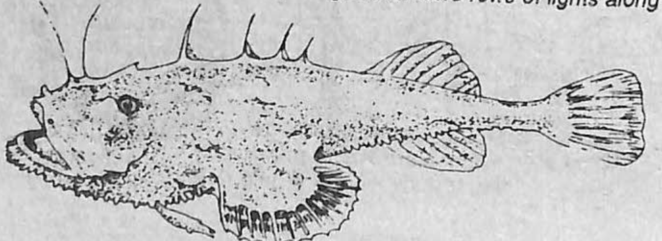


Fig 6.8 Special adaptations to deep sea life: the black swallower, which can distend its stomach to contain large prey

2. Deep sea animals are weak and frail. This is due to the absence of water movements or currents at the depths.
3. Another interesting features is the presence of a riot of colours. Red seems to predominate over other colours, e.g., deep sea star fishes, crustaceans, etc.
4. Deep sea animals are predatory in their habits, i.e., they hunt other animals for their food.

   Bioluminescence (light emitted by living organisms) is rather widespread among deep sea forms.
6. Some deep-sea fishes have telescopic eyes, e.g., gigantura.
7. In some forms the eyes are not well-developed. As a sort of compensating measure deep sea crustaceans and fishes having developed long feelers.
8. *Muciferous glands* and the *lateral line system* are characteristics of deep sea forms.

FRESHWATER HABITAT

In a typical tropical lake (lentic biota) for example, life is abundant at the margins which are exposed during the dry period. The common rooted plants

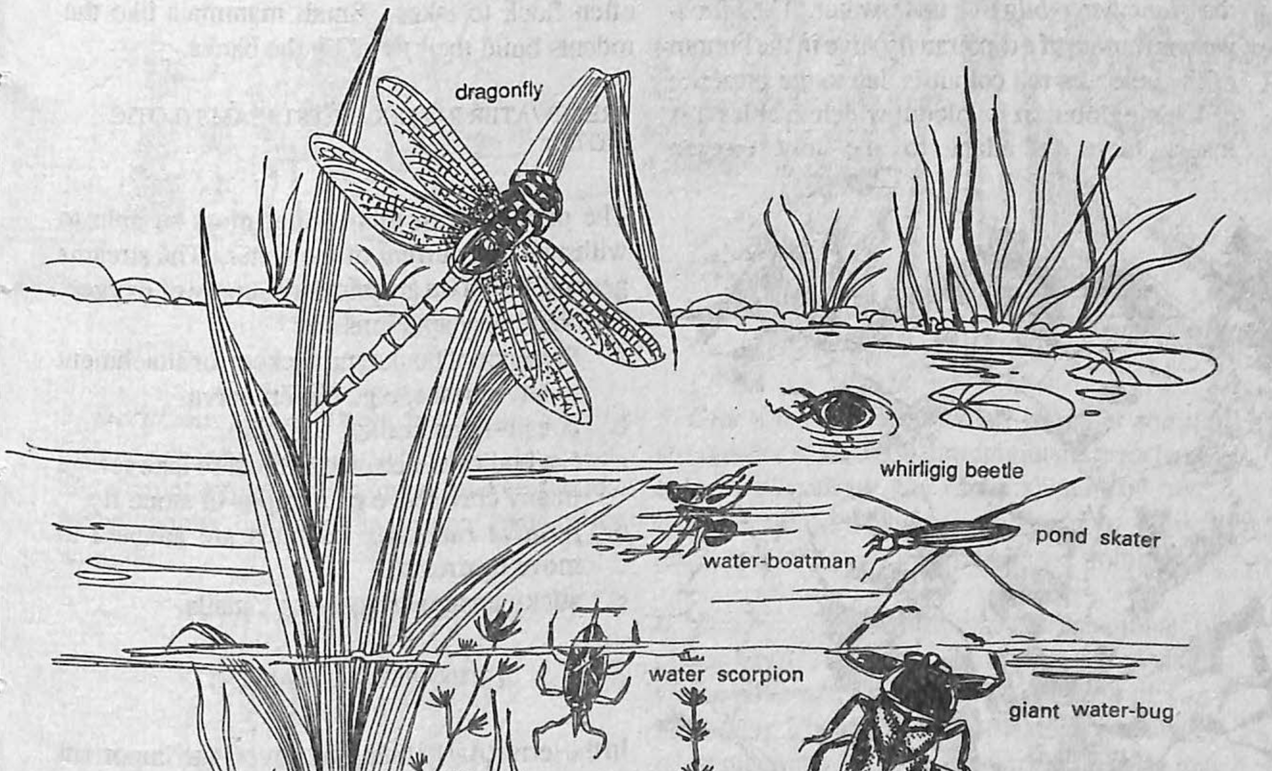


Fig. 6.9 The invertebrate fauna of a freshwater habitat.

that fringe the pond are reeds and sedges, while the common floating plants are water lilies and waterlettuces. *Chlamydomonas*, blue-green algae and diatoms occur freely floating on the surface of the lake. These common microscopic forms make up the *phytoplankton* of the pond and are quite similar to the marine forms. The *zooplankton* consists mainly of *copepods* e.g. *cyclops* and *waterfleas* (daphnia) which are microscopic crustaceans. Among the annelids, leeches are common in fresh waters.

Insects found here are well adapted to their aquatic habitat. Some like *water-boatman* and the *giant water-bug* live underwater. The *blood-worms* (larvae of a dipteran fly) live in the bottom of the lake. Its red colour is due to the presence of haemoglobin in its blood, which enables this insect larva to adapt to the low oxygen concentration in the muddy bottom. The insects on the surface of ponds include the *whirligig beetle* and the *pond skater*. The latter has long legs with which it skates on the surface of ponds. The predatory dragonflies are the common airborne insects of tropical ponds. The *dragonfly nymphs* live underwater among rocks or stones and voraciously feed on small aquatic organisms.

Fig. 6.10 A stream

Among the vertebrates of the lake, fishes are most abundant. *Reed fish* and *lung fish* are common lake dwellers. The amphibians found here are toads. A few water snakes make up the reptilian fauna. Wading birds like flamingoes often flock to lakes. Small mammals like the rodents build their nests by the banks.

FRESHWATER RIVERS AND STREAMS (LOTIC BIOTA)

The organisms in this habitat must be able to withstand the current of the water. The streams generally contain an abundant supply of oxygen. The various adaptations are:

a. Presence of hooks and suckers for attachment to any surface, e.g., diptera larva.
b. stream-lined bodies, e.g., fish.
c. flat bodies which enable them to take refuge in any crevices, e.g., nymphs of stone fly.
d. *positive rheotaxis* (animals are adapted to move upstream).
e. sticky under surfaces, e.g., snails.

TERRESTRIAL HABITAT

In the terrestrial habitat, soil cover is an important substratum as it constitutes the bulk of the habitable part of the land. Rainfall is the most important factor in determining the type of vegetation in a terrestrial habitat. The fauna of this habitat is associated with the types of vegetation. The terrestrial habitat can be divided into the following major types. 1. *Tundra*, 2. *Coniferous forest* 3. *Deciduous forest*, 4. *Tropical forest*, 5. *Grassland* and 6. *Desert*.

1. Tundra: The tundra is characterised by snow, ice and frozen soil most of the year. The tundra is treeless. It consists of mosses, sedges and a few grasses. *Caribou, arctic hares, foxes* and *migrating birds* are common.

2. Coniferous forest: The coniferous forest is characterised by coniferous trees. These evergreen trees consist of pine, cedar, spruce, etc. Many lakes and peat bogs are characteristics of this region. It is an excellent habitat for elk deer, squirrels, ground rabbit and birds.

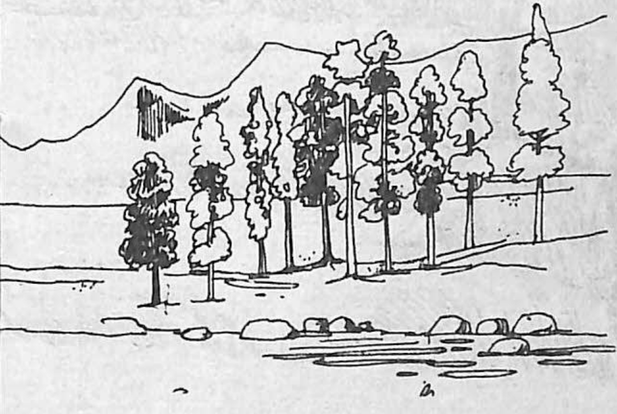


Fig. 6.11 Coniferous forest

3. Deciduous forest: These forests are usually formed of hardwood trees such as oak, elm, beech and maple. Frogs, turtles, many snakes, lizards, foxes, rabbits, deer and racoons are some of the animals.

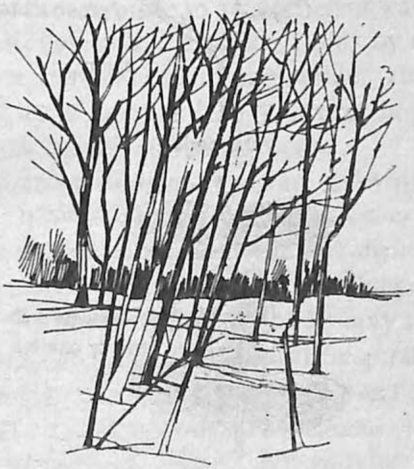


Fig. 6.11 Deciduous forest in winter

4. Tropical forest: The climate of the tropical forest is warm and humid. The tall trees form an open canopy. Ferns and herbaceous plants are common on the jungle floor. The animals include various snakes, monkeys, large carnivores such as leopards, tigers and lions.

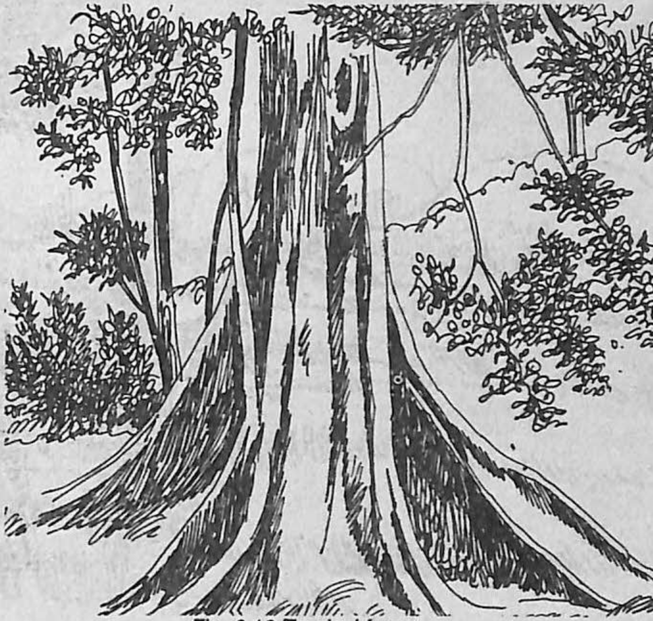


Fig. 6.12 Tropical forest

5. Grasslands: The rainfall is irregular and the strong winds, common throughout the grasslands, help to discourage the establishment of trees. Grazing animals dominate this region. Prairie dogs, antelopes and jack rabbits are common.

6. Desert: Deserts are typical examples of physically dry habitats. The three types of plants are *ephemerals, succulents* and *perennial non-succulents*. The succulents contain a large quantity of stored water. Common succulents are Aloe, Agave and cacti. The surface is covered over with thick cuticle and wax. In opuntia the leaves are modified into spines. Photosynthesis is carried out by green and succulent stems. In Aloe where the stem is reduced, the leaves are succulent. Perennial non-succulent xerophytes have a number of adaptations to reduce transpiration. *Nerium* has shining leaf surfaces. The leaves are leathery, there is a thick cuticle, multi-layered

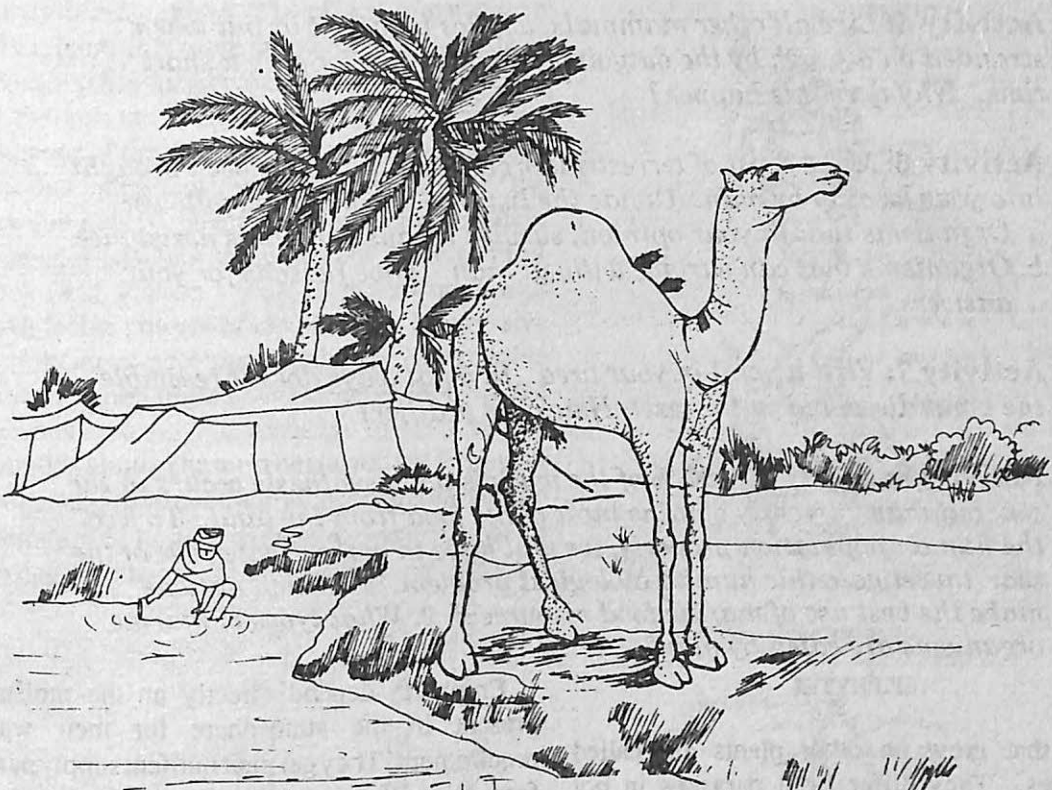


Fig. 6.16 Desert with oasis

epidermis and stomata sunken in cavities.

The animals of the desert are of two types. Either they manage to get sufficient water or are able to conserve their body fluids by reducing evaporation and loss through urine. The former category of animals feed on succulent plants or animals having sufficient blood.

Camels and *kangaroorats* are the two mammals which have adapted themselves to conserve water. They do not produce sweat and their urine is highly concentrated. Kangaroorat does not drink water. It feeds on dry seeds. Its only source of water is the one produced during respiration, i.e., *metabolic water*. Camels drink water and they can also store water in special pouches. They also avail of metabolic water. Their cells can undergo dehydration upto 30 - 40%.

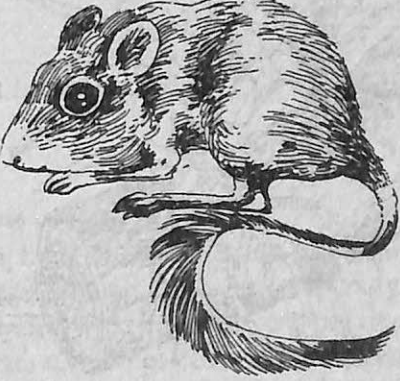


Fig. 6.17 Kangaroorat.

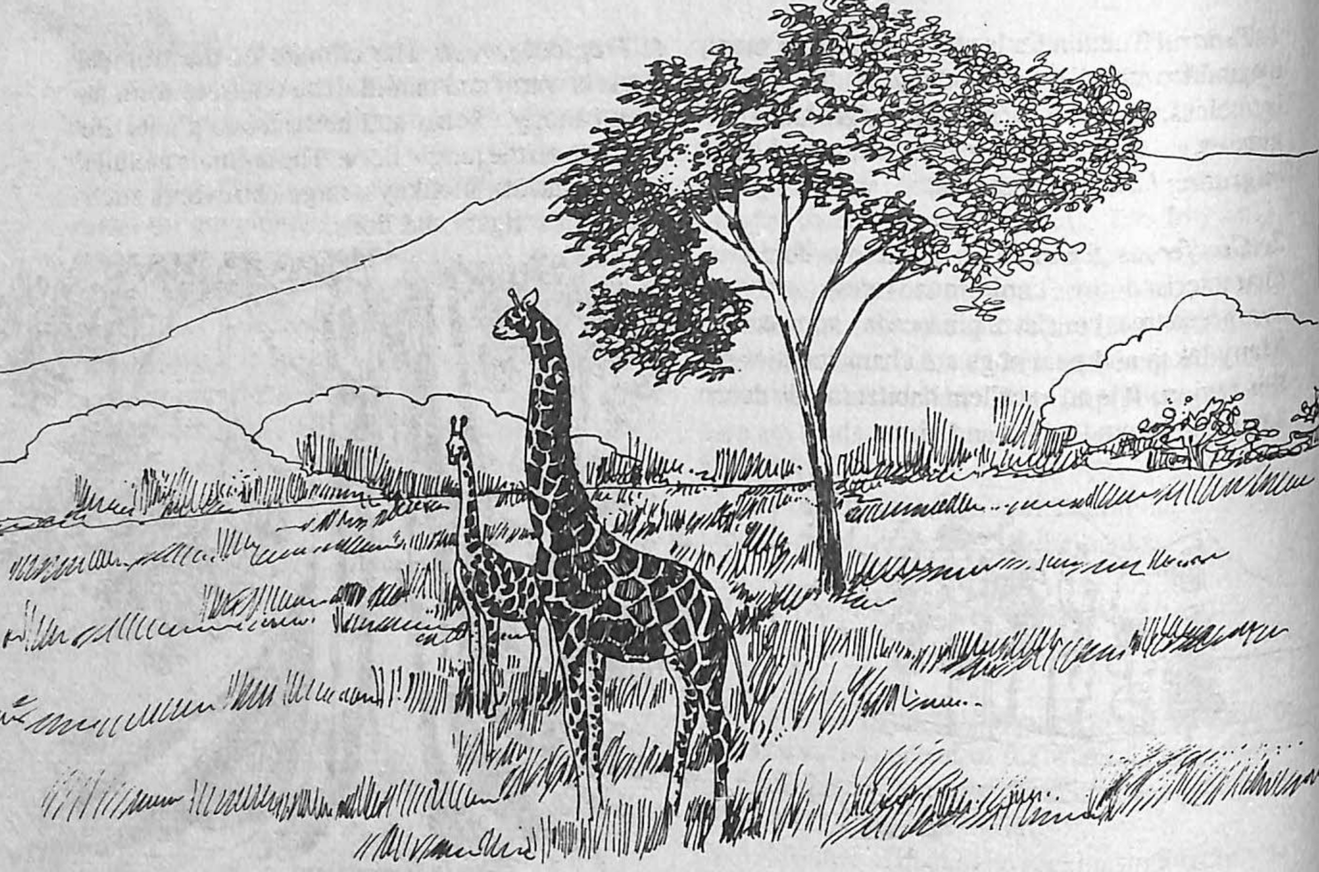


Fig. 6.13 Grassland

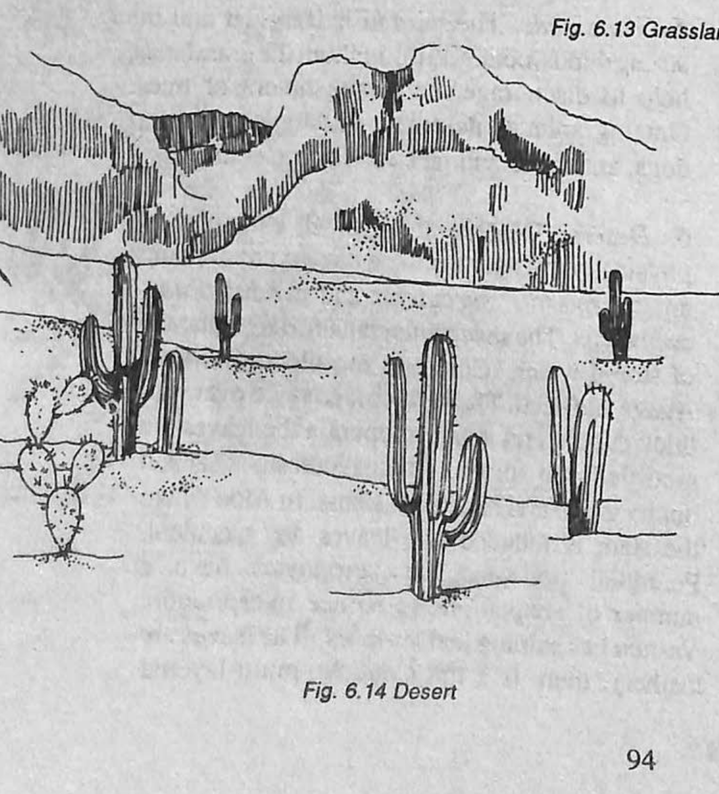
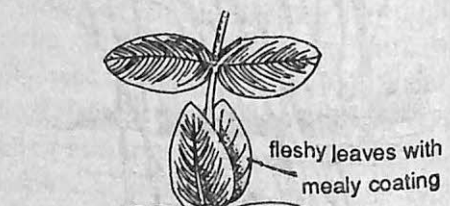
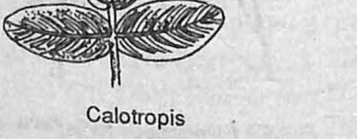


Fig. 6.14 Desert



Capparis



Calotropis

Fig. 6.15 Non-succulent xerophytes

Activity 5: *Like all other mammals, whales breathe air; but when stranded on a beach by the outgoing tide, they live for only a short time. Why does this happen?*

Activity 6: *Make a list of terrestrial organisms that have been brought into your locality by man. Divide the list into two parts, as follows:*
a. Organisms that in your opinion, survive because of man's assistance.
b. Organisms that can survive without man. Give reasons for your answers.

Activity 7: *Visit a pond in your area. In what ways does it resemble the pond discussed in the text? How does it differ?*

Activity 8: *Nearly 80 - 90 % of the world's photosynthesis occurs in the sea; but man currently obtains most of his food from the land. To feed the human population properly, we will have to make greater use of the sea. Investigate this human biological problem. 1. Which nations make the best use of marine food resources? 2. What types of marine organisms are eaten by man?*

EPIPHYTES

Plants that grow on other plants are called epiphytes. They differ from parasites in not deriving food or water from the supporting plants. e.g., Vanda.

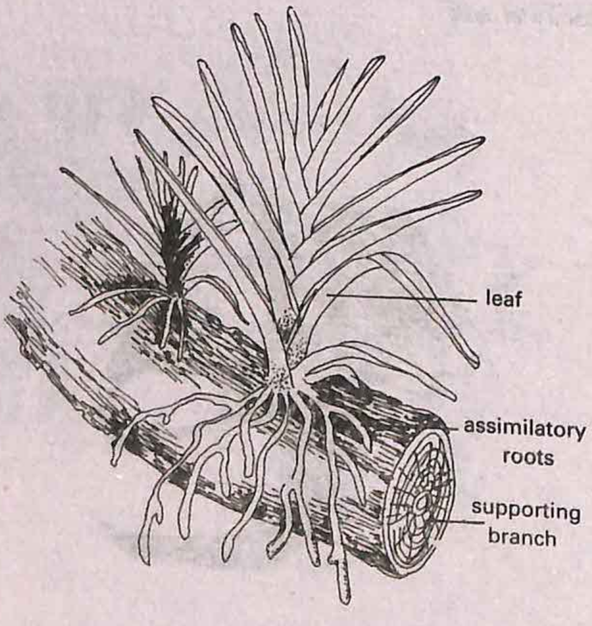


Fig. 6.18 Epiphyte: Vanda

Epiphytes depend directly on the moisture present in the atmosphere for their water requirement. They get their nutrient supply partly from rain water containing dissolved substances, partly from the accumulated wind borne particles and partly from the decaying bark surface of the supporting plants.

Vanda is an epiphyte. Its leaves are thick and occur in two alternating rows. Vanda produces aerial roots, which are thick and white. The special cells constitute *velamen tissue* which absorbs water from the atmosphere. The water that is absorbed will be utilised by the epiphyte to carry on several vital processes such as photosynthesis.

PARASITES

A parasite is an organism which establishes a close and intimate physiological relationship with another organism, usually stronger than itself, called the host. It is a one-sided relationship for the parasite always gets the benefit and the host is injured in some way or other.

Parasitic adaptations: The effects of parasitism on the parasite is more pronounced in the case of endoparasites than ectoparasites. The structure of the parasite is highly modified to meet the demands of the peculiar environment of the host. Another important feature that is seen is, the development of the organs of attachment. These organs of attachment are present in the form of hooks and suckers. Most of the endoparasites have feeble powers of locomotion. Progressive parasitism is accompanied by the progressive loss of sense organs and degeneration of the nervous system. The digestive tract undergoes simplification. The most characteristic feature of the parasitic forms is the presence of a complicated reproductive system with an excessive capacity for egg production. Therefore, most parasites are hermaphrodites. Another remarkable feature of the parasitic animals is the complexity of their life cycles. Parasites also exhibit *anoxybiotic* respiration, i.e., they can live in the absence of the oxygen as, for example, the intestinal worms (anaerobic respiration).

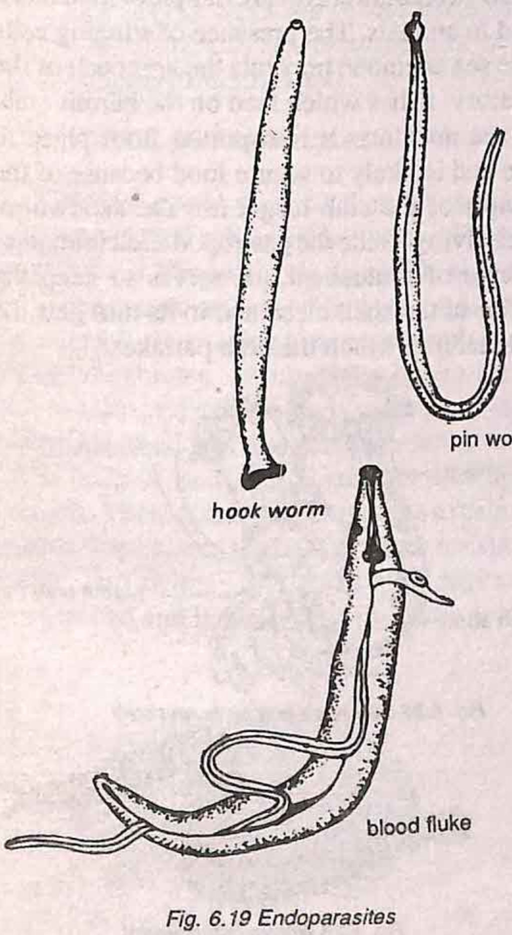


Fig. 6.19 Endoparasites

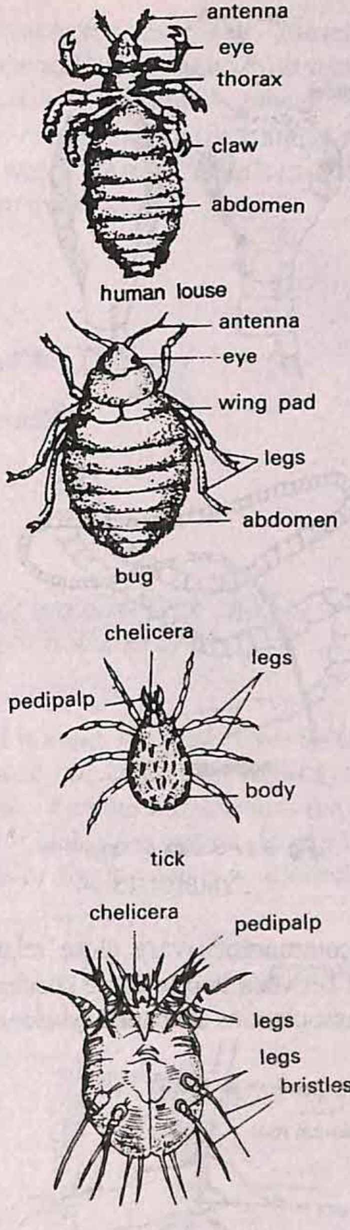


Fig. 6.20 Ectoparasites

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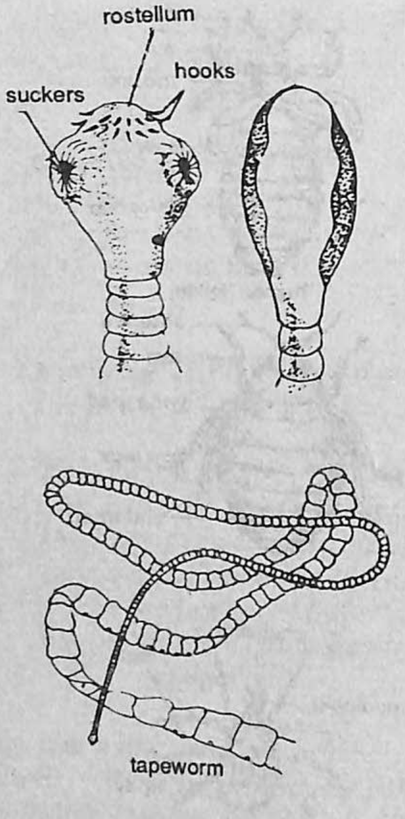


Fig. 6.21 Scolex of tapeworm

SYMBIONTS:

In most communities very close relationships may exist between two or more species. These intimate associations are called *symbiosis* (living together) and the two individuals in this case are called symbionts. The roots of most legumes produce *nodules*. These root nodules are inhabited by bacteria, *Rhizobium (sp)*. These bacteria (bacteroids) fix atmospheric nitrogen into organic compounds which are in turn utilised by the legume. The host plant in turn supplies the parasite with food and water. The two organisms, the legume and the bacterium, Rhizobium (sp) live together and are mutually benefitted.

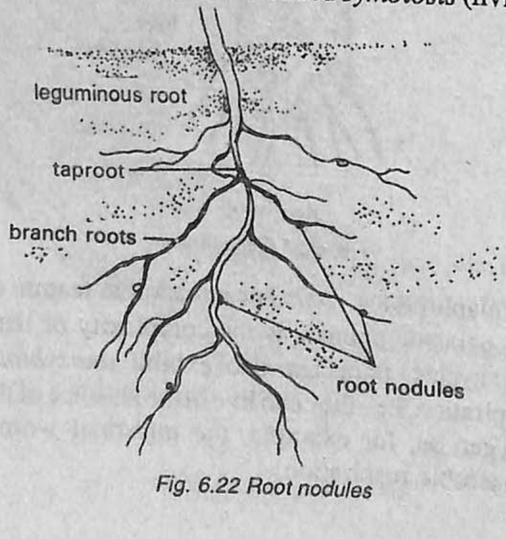


Fig. 6.22 Root nodules

The major categories of symbiosis are *mutualism* and *commensalism*.

Mutualism

A relationship between two dissimilar organisms that are mutually beneficial is called mutualism. The association between the sea-anemone and the hermit crab is a classical example of mutualism found in animals. The presence of stinging cells of the sea anemone prevents the approach of the predatory fishes which feed on the hermit crab. The sea anemone is transported from place to place and is likely to secure food because of the attempts of the crab to get it. The sandworm, Nereis living inside the gastropod shell is another example of mutualism. It serves to keep the interior of the shell clean and in its turn gets the food material which the crab partakes.

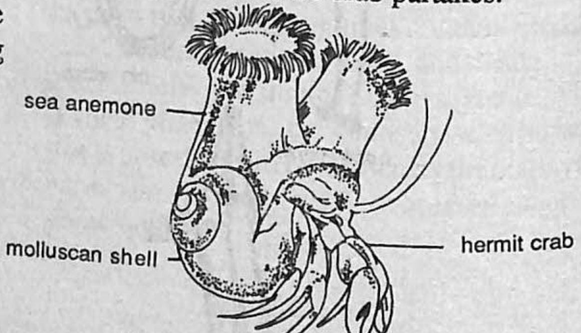


Fig. 6.23 Sea anemone on hermit crab

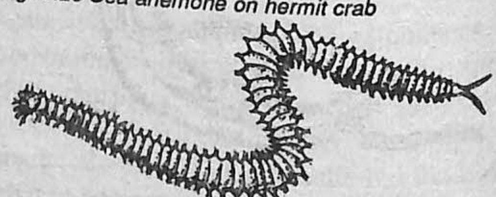


Fig. 6.24 Nereis (sand worm)

Commensalism:

The term commensalism literally means 'eating at the same table'. Commensals which are attached to the outer surface of the host are referred to as *ectocommensals*. If the commensals are found inside the body of the host they are referred to as *endocommensals*. The relationship between the remora (sucker fish) and the shark is a good example of commensalism. The dorsal fin of the remora is modified into a sucker by means of which the remora can form a temporary attachment to the shark.

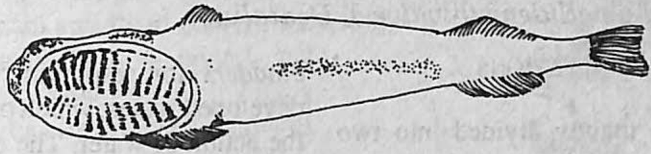


Fig. 6.25 Suckerfish

Activity 9: ***Observe the preserved specimens of sea anemone and hermit crab; remora and the shark; and the root nodules of a leguminous plant.***

FOSSORIAL (BURROWING) ADAPTATIONS

Animals that spend most of their lives underground are called subterranean forms. They are adapted for a burrowing mode of life and their body structures are modified to suit their environment. Burrowing forms commonly occur among vertebrates. Among the invertebrates, they are restricted to a few phyla such as, annelida, arthropoda, mollusca and echinodermata.

The body of the fossorial animals is compact and rigid. These animals often possess a fusiform or spiral shaped body which offers least resistance during burrowing. The shoulder region is strengthened and is wider than the other points. The tail is either reduced or vestigeal.

A reduced tail is seen in the *hedgehog* and *woodchunk*. Another adaptation is the presence of some sort of digging organs. In pigs the snout often helps in digging and is well developed.

Fig. 6.26 Hedgehog

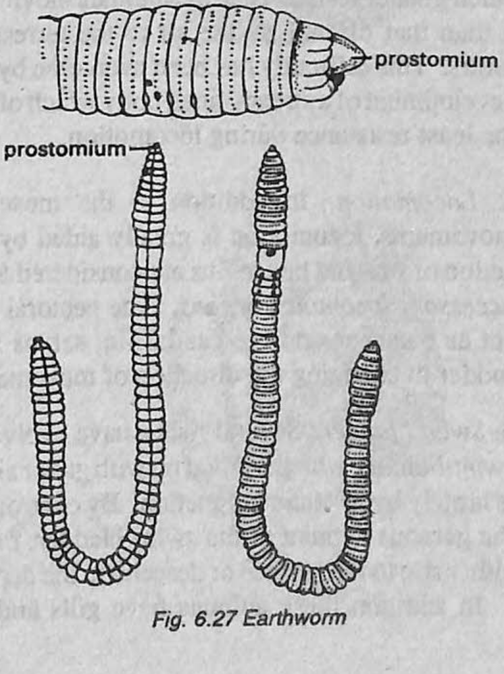


Fig. 6.27 Earthworm

The most important modification for fossorial life is seen in the structure of the forelimbs. The limbs of the fossorial animals are short and stout and thus they are at an advantage mechanically. The hand, particularly, is broad and stout and it is armed with strong claws. Another physiological behaviour that is seen in fossorial animals is *winter sleep* or *hibernation.*

In the earthworm the *prostomium* is well-developed which helps it burrow. In the *mole cricket,* the forelegs are specially módified for digging. The holothurian *synapta* is a typical burrowing echinodeim. It burrows into sand and mud.

Activity 10: *Find out how the following molluses are adapted to their burrowing mode of life. Draw figures and label only the burrowing organs. a. Lamellidens (bivalves), Dentalium.*

AQUATIC ADAPTATIONS

Aquatic animals are mainly divided into two types, namely *primarily aquatic* animals and *secondarily aquatic* animals. Animals that live only in water are the primarily aquatic animals, (e.g., fish). Secondarily aquatic animals are those which have adapted to water but are derived from terrestrial ancestors, e.g., crocodiles, turtles, hippopotamus, sea-lions, dolphins, etc. which are all lung breathers.

The following adaptations are seen in aquatic animals:

1. *Stream-lined body:* The watery medium affords much greater resistance to the animals moving in it than that offered by the air to the terrestrial forms. This difficulty has been overcome by the development of a stream-lined body which offers the least resistance during locomotion.

2. *Locomotion:* In addition to the muscular movements, locomotion is greatly aided by the action of fins and hence fins are considered to be *accessory locomotor organs.* The pectoral fins act as balances and the caudal fin, serves as a rudder in changing the direction of movement.

3. *Swim bladder:* Several fishes have evolved a *swim-bladder* which is filled up with gas or air. It is largely hydrostatic in function. By controlling the gaseous content of the swim-bladder, fishes either rise to the surface or descend to the depths.

In addition these animals have gills and *air bladders* for respiration. They possess well developed scales, which protect the body against the action of water. The characteristic presence of lateral line sense organs is another feature which helps in the detection of pressure and temperature. *Muciferous* glands prevent the diffusion of water through body surface.

SECONDARILY AQUATIC ADAPTATIONS.

The following adaptations an seen in the secondarily aquatic animals.

1. Body contour: The body contour has become stream-lined. In certain vertebrates, a pair of *flippers* aid in balancing and steering.

2. *Skeleton:* The skull undergoes modifications forming a slender *snout* or *rostrum.* Turtles have a long neck and this helps in the capture of the prey. In certain vertebrates, the vertebral column is reduced and the bones are light and spongy. In the whale the inner spaces are filled up with oil.

Locomotion: The pentadactyl limbs of terrestrial mammals are of no use to acquatic forms. This difficulty has been overcome by the development of great tail flukes with powerful musculature. In whales and dolphins the forelimbs are modified to form paddles without any external trace of digits. The tail flukes are expanded horizontally and their vertical movements help to propel the animal forward. The paddle-like nature of the limbs is because of the flattening of the bones.

Respiration: The problem of respiration is acutely felt by the secondarily aquatic forms which are lung breathers as they may have to stay under water for long spells. Muscular flaps serve to keep the nostrils closed when the animals are diving. The epiglottis is specialised to form a tube which serves as an air-way from the internal nostrils to the larynx. Special muscles have been developed in the bronchi and these prevent the animal from suffocation during diving and feeding. The lungs are known for their highly elastic nature and they can store large volumes of air.

Integument: The loss of armour, hair and skin glands is very characteristic of the aquatic animals. The glands of the skins are of no importance and hence they are reduced. The surface of the eye is protected by a secretion from the *harderian glands*. The external auditory opening is also reduced.

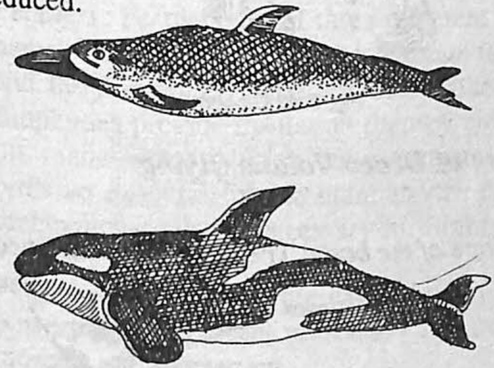


Fig. 6.28 Dolphin and whale

ARBOREAL OR SCANSORIAL ADAPTATIONS:

Animals inhabiting trees are said to lead an arboreal mode of life. Three different types of arboreal animals can be distinguished based upon their adaptations to an arboreal mode of life. They are 1. wall and rock climbers (e.g., geckos) 2. terrestrial - arboreal forms, e.g., sloth bear, tigers, flying squirrels. 3. arboreal forms (lemurs and chameleons)

Fig. 6.29 Spider monkey

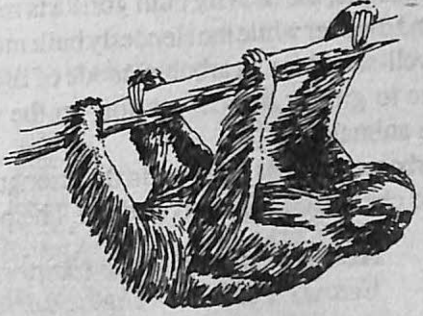


Fig. 6.30 Sloth bear

Fig. 6.31 Ring-tailed lemur

True arboreal adaptations are found among tree dwellers. The arboreal forms based upon this type are sub-divided into three groups. They are: a. branch runners b. forms suspended beneath branches, and c. forms swinging by the forelimbs.

Squirrels, lemurs and chameleons are examples of *branch runners*. They are capable of swift movement over branches. *True arboreal* adaptations are found among lemurs and chameleons. The sloths walk upside down changing on to branches with the help of the powerfully built recurved claws on the forelimbs. The primates (gibbons and apes) are examples of the third category. With the help of the elongated forelimbs, they swing, from branch to branch, or from tree to tree, with remarkable precision and speed.

Arboreal habit imposes a size limitation especially so in the case of arboreal mammals. For example, the heavily built gorilla is mainly a ground dweller while the slenderly built monkeys are well-suited for an arboreal mode of life. This is due to greater muscular effort on the part of these animals.

Arboreal life has resulted in the strengthening of the chest, ribs and limb girdles. The pectoral girdle is powerfully built and it has a prominent clavicle (collar bone) and scapula (shoulder blade). The development of claws, opposable toes, suction discs, prehensile tail and parachuting mechanisms are wide-spread among the divergent arboreal forms.

Fig. 6.32 Gibbon

Activity 11: *Observe the preserved specimen of Draco Volans (flying lizard) and write the adaptive features.*

VOLANT (FLYING) ADAPTATIONS:

Animals inhabiting the aerial environment show many adaptations for the aerial mode of life. These animals are known as volant forms. Volant adaptations are seen in fishes, amphibians, reptiles, birds and mammals among vertebrates. Among the invertebrates, insects alone exhibit volant adaptations.

Flight is of two types in animals: 1. active or true flight and 2. passive flight (gliding)

Mechanism of flight in birds:

In order to achieve efficient and sustained flight, birds have undergone the following structural modifications.

The shape of the body: The body is stream-lined

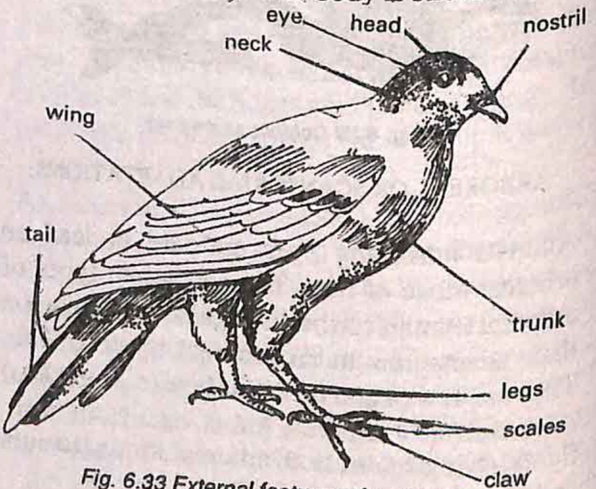


Fig. 6.33 External features of a pigeon

and thus offers the least amount of resistance for movement in the air.

The wing: The wing is a composite structure formed of skeletal muscles, nerves, blood vessels and feathers. The wing of a bird is a modified forelimb of other vertebrates.

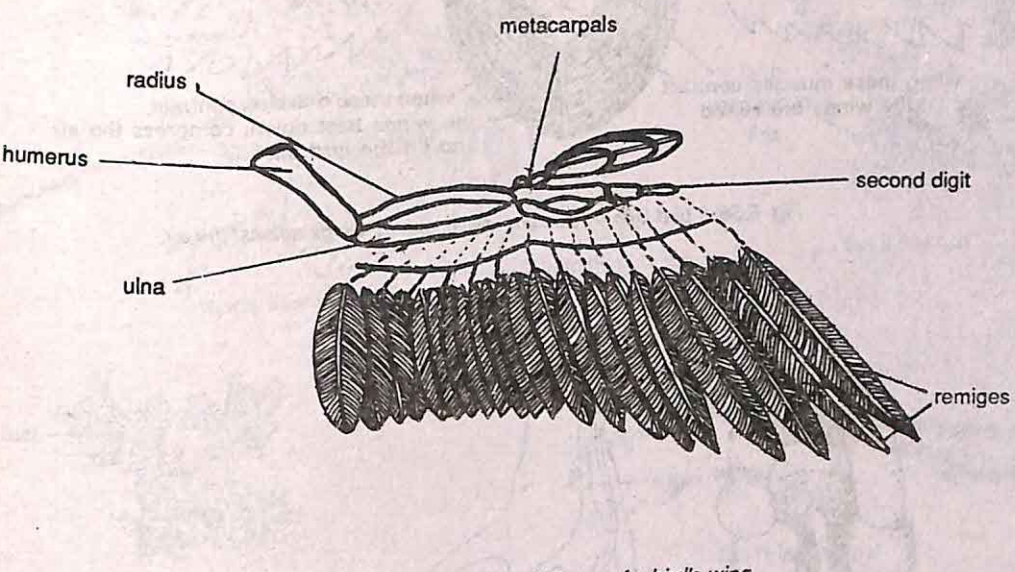


Fig. 6.34 Feathers and skeleton of a bird's wing

Feathers: Feathers are of three different kinds, namely, the *quill* feathers, the *contour* feathers and the *filoplumes*. The contour feathers and filoplumes provide insulation thereby aiding in the maintenance of high body temperature of birds so essential for the maintenance of high metabolic rate that is necessary for flight.

Flight muscles: Wings are worked upon by the powerfully built flight muscles. The pectoral muscles are very strong.

Reduction in body weight: The reduction in the body weight to facilitate easy flight is brought about by the *pneumaticity* of the bones. The pneumaticity of the bones is effected by the extension of the air sacs in the cavity of bones.

The bones of the skull are almost thin and are completely fused thus having the ability to withstand the effects of varying pressures of air. The vertebral column is rigid except for the cervical region (neck region).

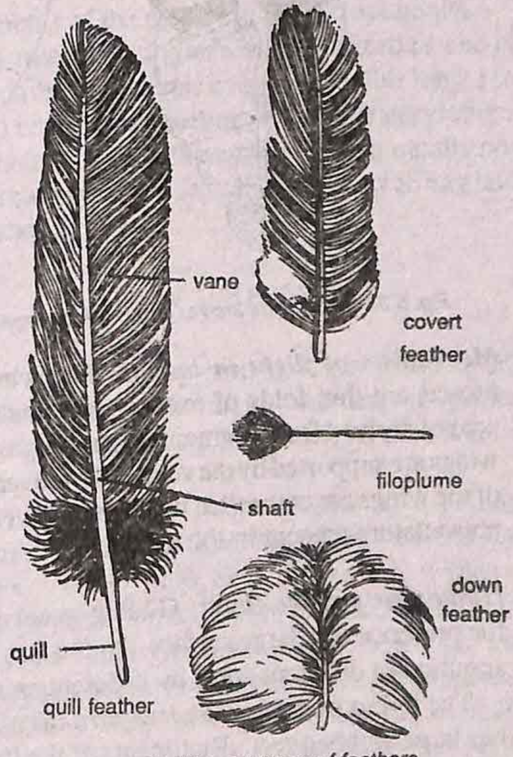


Fig. 6.35 Different types of feathers

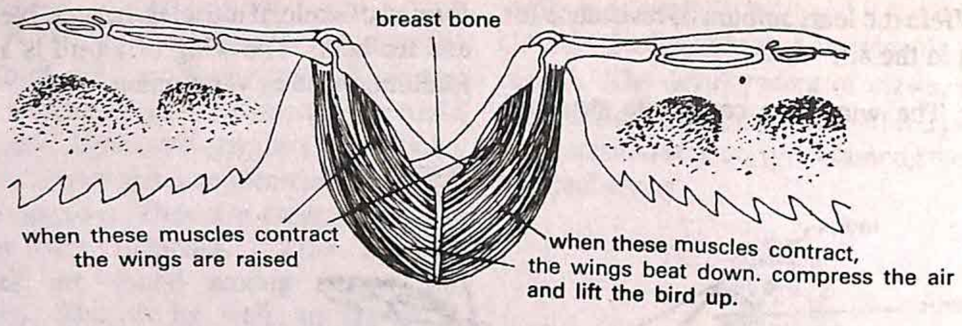

breast bone
when these muscles contract the wings are raised
when these muscles contract, the wings beat down. compress the air and lift the bird up.

Fig. 6.36 A bird flies by pushing down with its wings against the air.

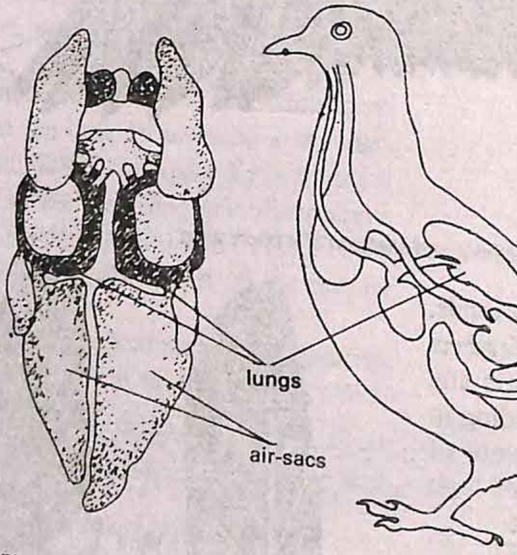


Fig. 6.37 Birds' lungs lead to a network of large air sacs which keep the bird light and can take in plenty of oxygen

Mechanism of flight in insects: The wings of insects are thin folds of exoskeletal cuticle and are not derived from segmental appendages. The wings are supported by the veins. The movements of the wings are controlled by the well developed musculature present in the thorax.

Gliding or passive flight: Gliding necessitates the presence of a large surface and this has been acquired in different ways by different animals.

The flying frog *Rhacophorus pardalis* of Java has large webbed feet. Rudiments of the fold of skin are found in front as well as behind the arms.

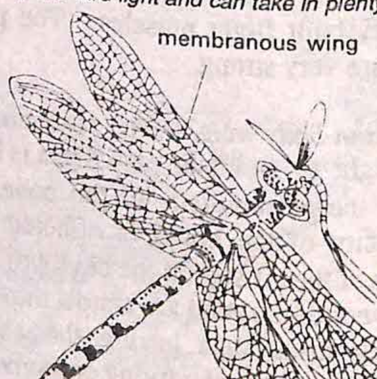


Fig. 6.38 Dragonfly

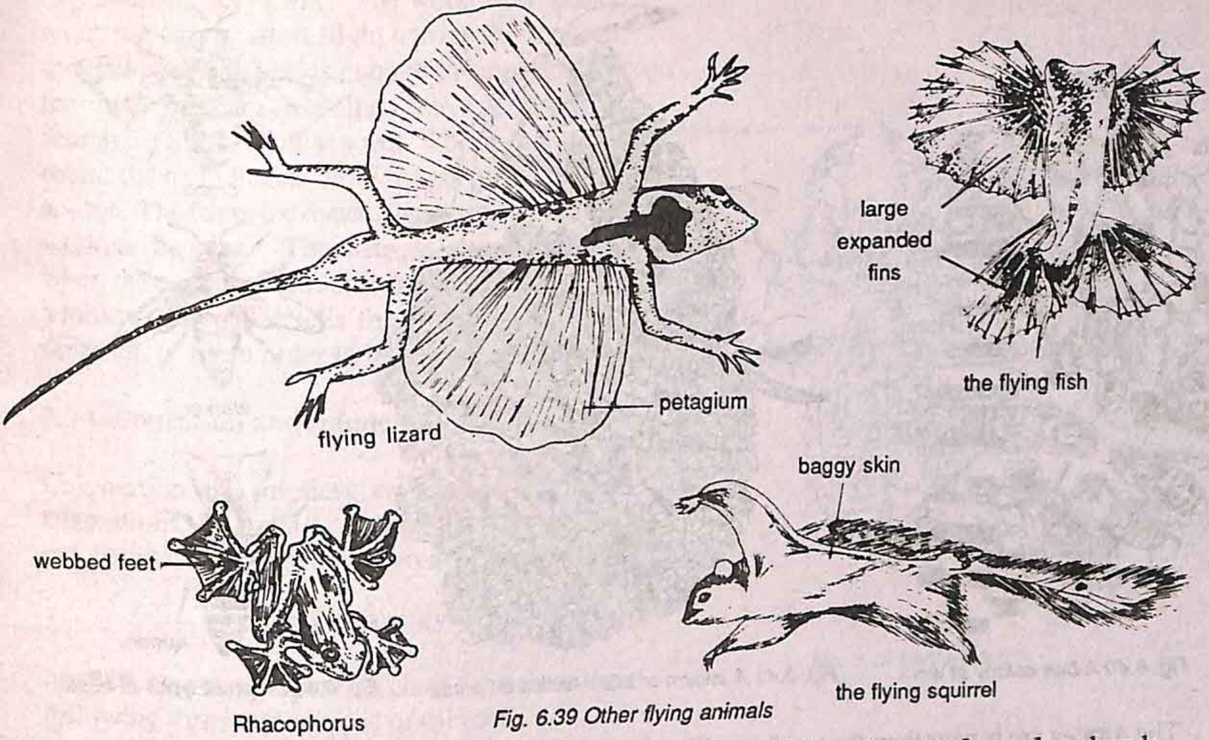


Fig. 6.39 Other flying animals

The flying dragon, Draco volans has a flexible membrane (patagium) projecting from the sides of the trunk. In between the expansion is supported by 5 to 6 ribs.

CHARACTERISTICS OF SOCIAL INSECTS

The social insects possess many common features.

1. In general, the insect societies are characterised by a large population.
2. There is mutual cooperation among the members of the colony.
3. There is division of labour and a clearly defined caste system.

SOCIAL LIFE OF BEES:

Cooperation is common between individuals in groups of animals. There are many examples of how much cooperation is built up among social insects, such as ants, bees, wasps and termites.

There are different views on why social insects show so much cooperation. One view is that feeding each other on regurgitated food helps members of the colony to form close bonds.

A true social insect may be defined as one in which the two parents live together, live longer so as to come in association with many generations of their progeny and many females mutually co-operate so that one female looks after an egg laid by another female.

LIFE OF THE HONEYBEE

A swarm of honey bees consists of 40 to 50 thousand bees. The major well known species are, *Apis mellifica, Apis indica, Apis dorsata* and *Apis florea.*

There are three kinds of bees in a colony namely the worker-bee, the queen bee and the drone. Nearly 90% of a swarm are workers. The workers collect nectar from flowers, build the hives, keep the hives clean, look after the newly hatched larvae and defend the hives against enemies. They have pollen baskets in their hindlegs for collecting pollen, wax-glands to build the hive and stings at the abdominal regions.

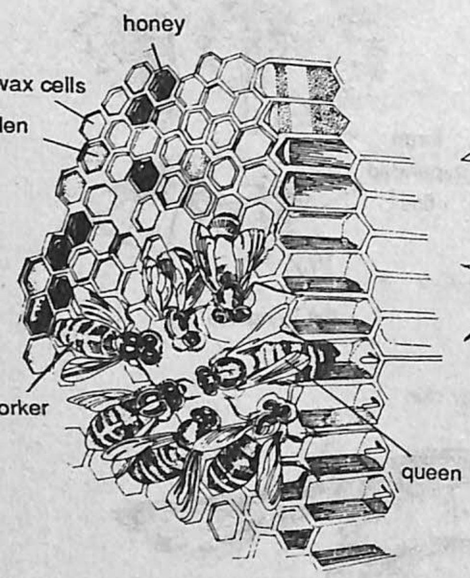


Fig. 6.40 A bee colony at work

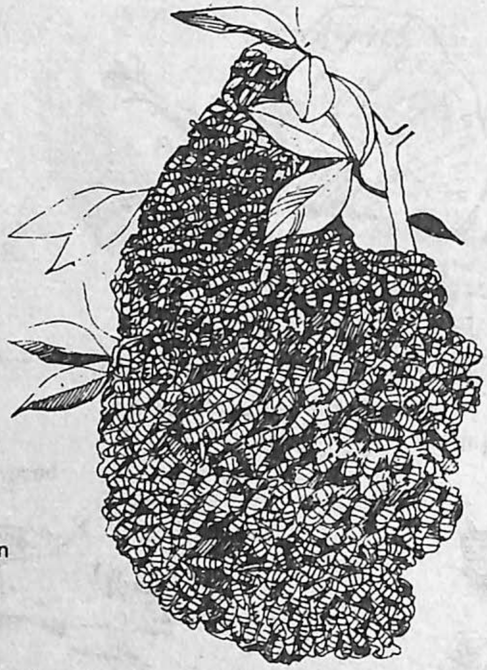


Fig. 6.41 A swarm of bees settles on a tree

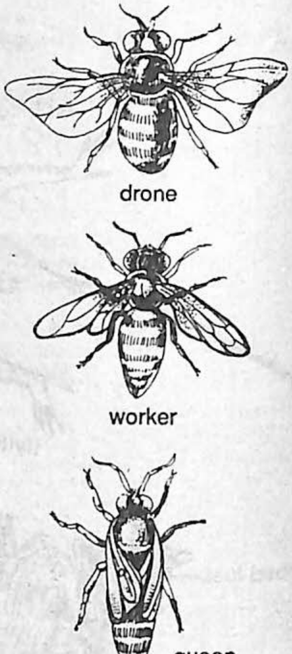


Fig. 6.42 Different types of bees

The drones are bigger than the workers. They have neither the pollen sac nor the wax-glands. They do not have stings. Their only function is to mate with the queen.

Each bee colony has only one queen bee. It is the only fertile female in a colony. The queen bee's function is to lay eggs and increase the bees population of a hive. Thus division of labour and social life are exhibited by the bee population.

Activity 12: *Do a short project on social behaviour . Choose one group of social insects and write a report about their behaviour.*

Round and waggle dance of bees:

A worker bee does a round dance when nectar is

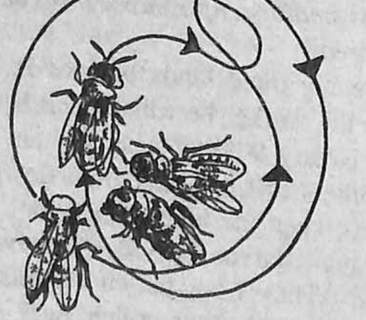


Fig. 6.43 Round dance of bees

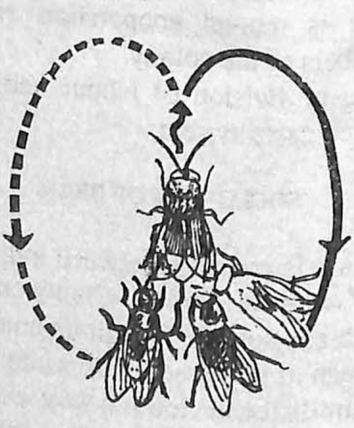


Fig. 6.44 Waggle dance of bees

less than 275 feet away. The worker obviously returning from a short flight carries the scent of the flower on it. This is enough information for the other workers, who then leave the hive to search for this particular scent. The speed of the round dance indicates the richness of the nectar source. The faster the dance, the more excited the workers become. The *waggle dance* is used when the nectar is farther than 275 feet away. In addition, this dance tells the workers in which direction to fly in order to locate the food.

6.4 Colouration and mimicry

Colouration and mimicry are special forms of adaptations in animals which are protective mechanisms to ensure the survival of the species.

KINDS OF MIMICRY

In 1889, Poulton proposed a classification of the following three major types of mimicry.

1. Apatetic: The term *apatetic* is applied when an insect resembles some object in its environment, i.e., an animal or a plant. Chameleons change colours according to the background on which it is on.

Sematic: This mimic possesses a close resemblance in colour and form to a species that is distasteful to predators. This may happen in any stage of the life cycle of an animal.

Epigamic: This is seen in species which exhibit sexual *dimorphism*. In certain cases, the males resemble a form that is distasteful to enemies while in others it is the females.

PROTECTIVE MIMICRY

The best example of protective mimicry is that of the *Kalima butterfly, Kallima inachis* of India. This butterfly has the upper side of the wings brilliantly coloured and is conspicuous

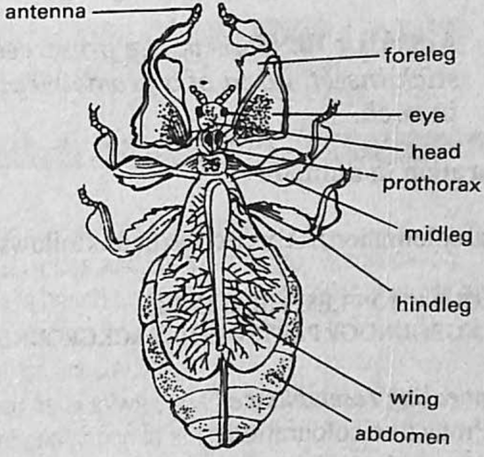


Fig. 6.45 Leaf insect

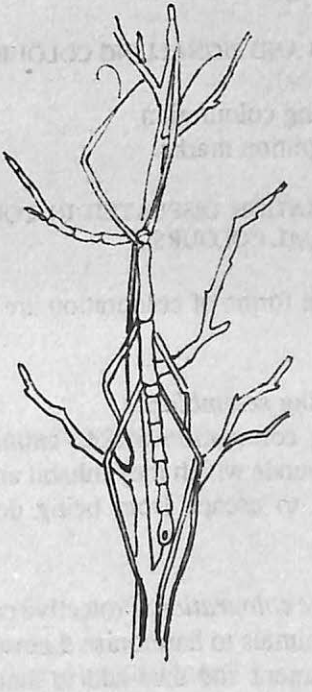


Fig. 6.46 Walking-stick insect

when in flight. The lower sides of its wings on the other hand are coloured like dead leaves.

When at rest the wings are held together over the back and thus hide the brilliantly coloured upper surface. When the butterfly is in this position, the resemblance to a dead leaf is remarkable.

Activity 13: *Observe the preserved specimens of leaf-insect, walking stick insect, larva of a geometrical moth and write the type of mimicry in each.*

Colouration in animals

Animal colouration has been classified as follows:

I COLOURATION RESEMBLING THE BACKGROUND OR PARTS OF THE BACKGROUND.

a. Concealing resemblance
  1. Protective colouration
  2. Aggressive colouration

b. False warning and signalling colouration
  1. Protective mimicry.
  2. Aggressive mimicry.
  3. Alluring colouration.

II WARNING AND SIGNALLING COLOURATION

  a. Warning colouration
  b. Recognition marks.

III COLOURATION DISPLAYED IN COURTSHIP OR SEXUAL COLOURS.

Some of the forms of colouration are described below:

Concealing resemblance
Concealing colouration makes animals match the backgrounds which they inhabit and thereby helps them to escape from being detected by enemies.

Protective colouration: Protective colouration helps the animals to harmonise themselves with the environment and thus add to their survival value. The resemblance of animals to their environment such as the green colour in the tropical rain forests, white colour in snowlands, etc. are some of the familiar examples. The crabs living among sea weeds, clothe themselves with pieces of weed and thus escape detection. The South American toad *Bufo typonius* is strikingly similar to the green background of the forest floor.

Aggressive colouration: Aggressive colouration is meant for terrifying or frightening another species. A turkey cock spreads its feathers and erects the coloured appendages on its head to frighten its rival or when fighting with its enemies or during courtship.

False warning and signalling colouration

Alluring colouration: Various species of preying mantis simulate the appearance of a mantis and thus attract other insects within the reach of its prehensile legs.

II REAL WARNING AND SIGNALLING COLOURATION

Recognition marks: Male fiddler crabs wave their brightly coloured claws when females are in sight. The bright markings on the eggs of sea-birds enable them to recognize their own eggs.

Warning colouration: This is characterised by conspicuous colours or markings that give notice to enemies. Bright hues such as red, yellow and black are found in some frogs with poisonous skin secretions. The poisonous lizard *Heloderma* *punctatum* is a notable example of warning colouration.

Sexual colouration: During the breeding season many animals are brightly coloured to attract their mates. The robin's breast becomes brilliantly red. Many male lizards display brighter colours during the mating season.

Activity 14: *Give a short account of the colouration displayed by the peacock, our national bird, during courtship.*

Some basic concepts

1. Adaptation of animals is the outcome of prodigality of production.
2. Animals tend to invade different ecological niches and finally undergo diversification.
3. Different types of adaptations in animals are based on the basis of nutritional habits and habitats.
4. The major habitats are: marine, terrestrial, freshwater.
5. Other nutritional relationships are classified as epiphytes, parasites and symbionts.
6. Adaptation to environment is a common phenomenon in animals.

Some suggested projects / activities

1. *In what ways may territorial behaviour by individual animals have selective advantage for the species in which it occurs.*
2. *Write a short account on the nest-building of birds, the web-building of spiders, and the comb-building of bees.*

REVISION

I *Answer the following questions.*

1. What is adaptation?
2. Define adaptive radiation.
3. Give an account of the different types of adaptations in animals.
4. Write a short account of the marine habitat.
5. Give a short account of the terrestrial habitat.
6. Give an account of the freshwater habitat.
7. Give an account of the social life of bees.
8. Compare the fauna of deciduous forest with that of the tropical forest.
9. What is the principal ability required of a species if it has to adapt to life in a city?

10. What land organisms show the most stream-lining? a. With what form of locomotion is this stream-lining associated? b. What water organism show the most stream-lining? c. With what kinds of niches is this stream-lining associated? d. Why do most planktons have little or no stream-lining?
11. Define mimicry and classify the three major types of mimicry?
12. What do you know about the Kallima butterfly?
13. Give a brief account of protective colouration, aggressive colouration and alluring colouration.
14. Write the significance of mimicry and colouration in animals.

II *Write notes on:*

a. parasites. b. symbionts. c. epiphytes. d. fossorial adaptation. e. aquatic adaptation. f. arboreal adaptation. g. volant adaptation. h. colouration. i. mimicry.

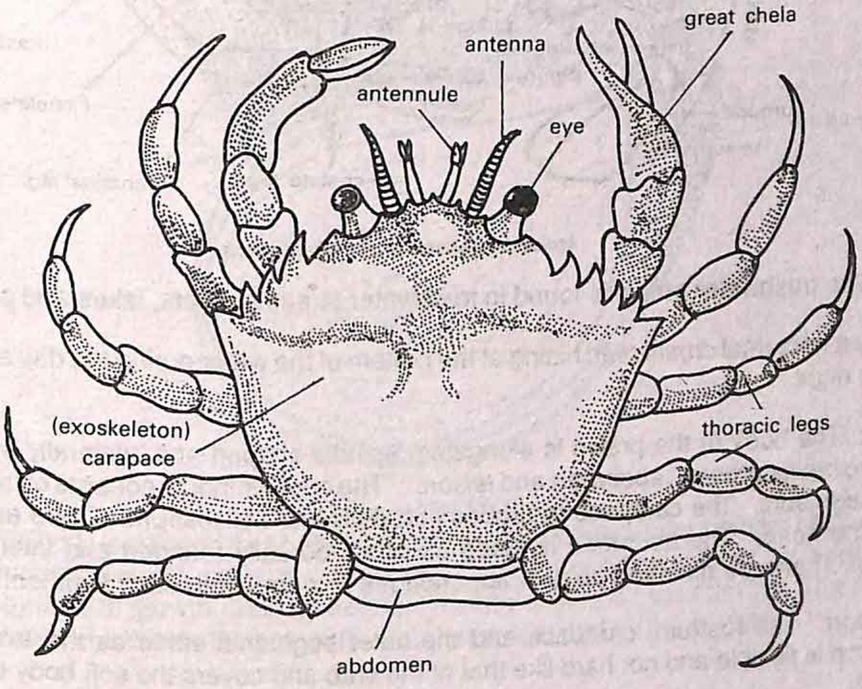
III *Differentiate between the following pairs:*

a. concealing resemblance and false warnings in animals.
b. signalling and protective colouration.
c. aggressive and alluring colouration.
d. mimicry and colouration in animals.
e. adaptation and adaptive radiation.
f. queen bee and drone.

PRACTICALS

I

The common crab (Carcinus)



The common crab (Carcinus)

Habitat: The common crab is found buried in mud in shallow water.

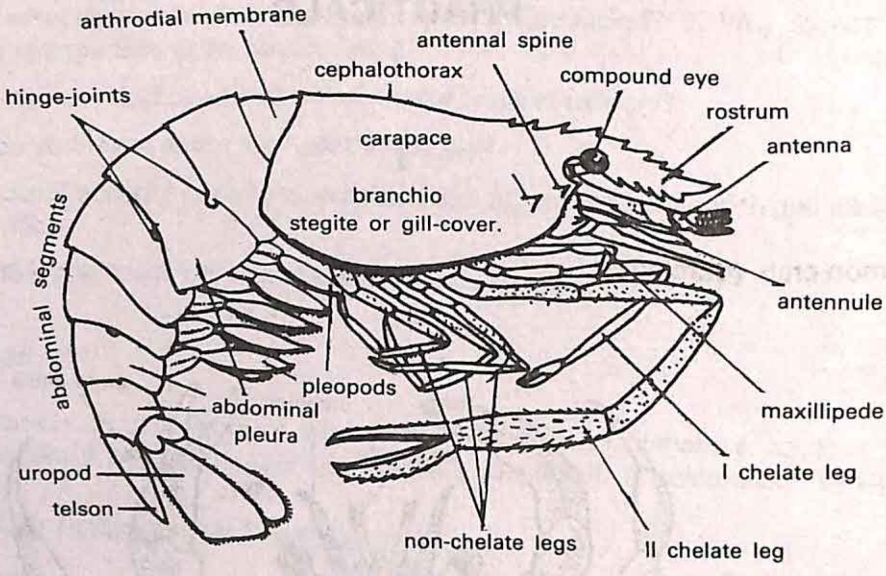
Habit: The crab is a specialised crustacean.

Structure: The body of the crab consists of a large and broad *cephalothorax.* The abdomen is reduced and fixed under the cephalothorax. The abdomen is narrow in male crabs but broad in a female.

The exoskeleton is a *carapace.* The antennules and eye stalks are embedded in the sockets of the carapace. The antennae are small and retractile as are the stalked eyes. The male has two pairs of *pleopods* whereas the female has four pairs.

Exoskeleton: The carapace serves as the exoskeleton covering the soft internal organs like a shield and protecting the animal.

b. Prawn *(Palaemon malcolmsoni)*



Indian freshwater prawn (Palaemon)

Habitat: The freshwater prawn is found in freshwater streams, rivers, lakes and ponds.

Habit: It is a nocturnal *crustacean* hiding at the bottom of the water during the day and coming to the surface at night.

Structure: The body of the prawn is elongated, spindle-shaped and bilaterally symmetrical. It is divided into *cephalothorax, abdomen* and *telson*. The cephalothorax consists of five head and eight thoracic segments. The carapace protrudes anteriorly into the *rostrum*. There are two prominent eyes on the head. The abdomen is made up of six dorsally rounded and laterally compressed segments. There are nineteen pairs of appendages — one pair in each segment.

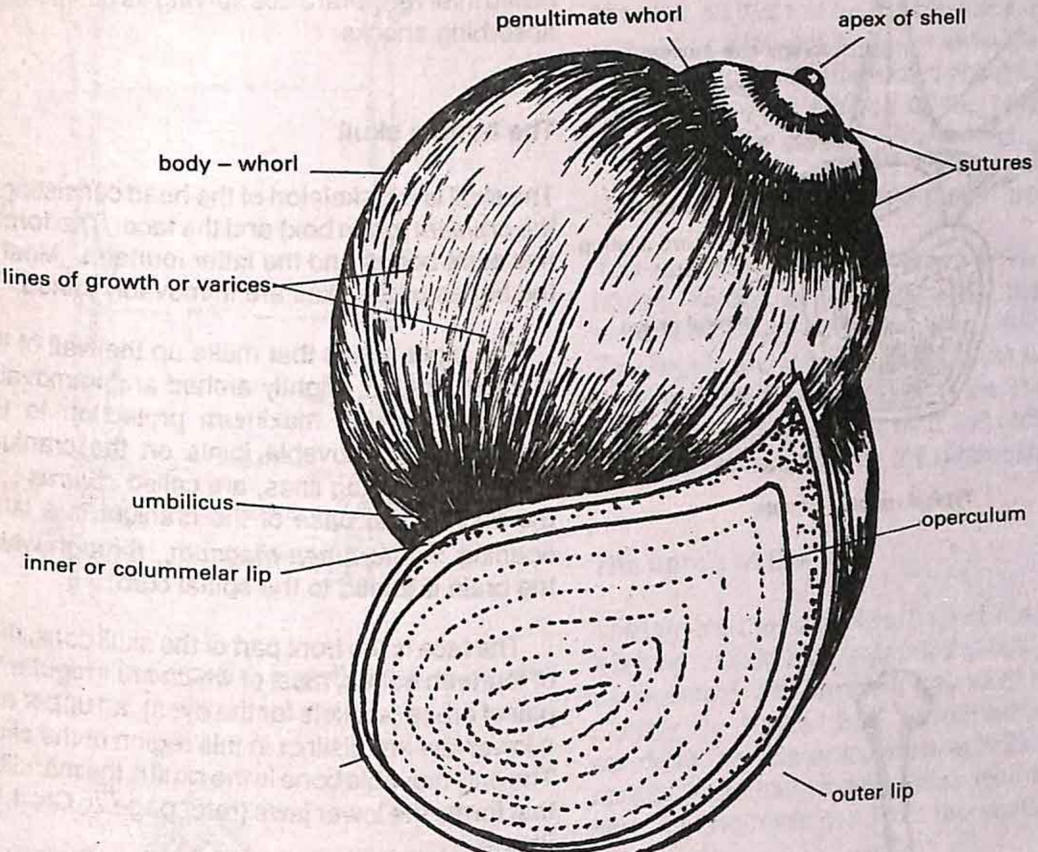
Exoskeleton: The rostrum, carapace and the outer segments serve as the *exoskeleton*. The exoskeleton is flexible and not hard like that of the crab and covers the soft body of the animal and protects it.

c. The apple snail *(Pila globosa)*

Habitat: The apple snail is one of the largest freshwater animals. It is found in tanks, ponds, paddy fields and in water having vegetation.

Habit: Pila globosa is a amphibious gastropod.

Structure: The body of the snail is covered by a shell, which is spiralled and coiled round an axis, called the *columella*. It opens to the exterior by the *mouth* or *aperture*. On removing the shell, the soft parts, i.e., *head, foot* and *visceral mass* are seen. There are two pairs of eyes. The foot is highly muscular. The visceral mass is spirally coiled and contains internal organs.



The apple snail (Pila)

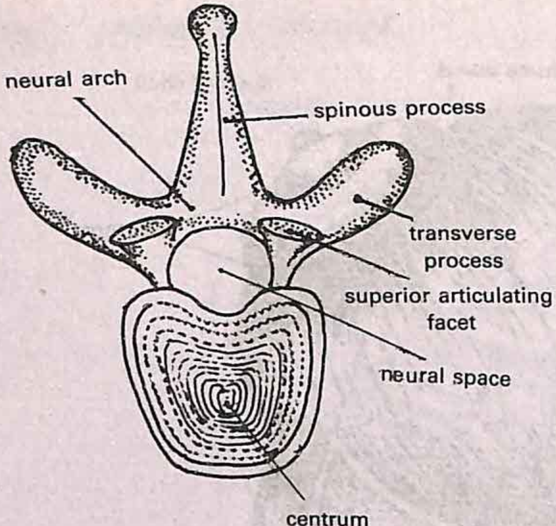
Exoskeleton: The body is covered by a thick, yellow or brown globular *univalve* hard shell, comprising *body whorl, penultimate whorl* and *apex*. Each region is separated by *sutures*. The surface of the shell is marked by lines of growth. This type of right handed coiling is called *dextral*. The shell serves as an exoskeleton and protects the soft parts, i.e., head, foot and visceral mass.

II

A typical vertebra of man

A typical vertebra contains a solid disc of bone called the *centrum*. Dorsally the centrum bears the *neural arch* enclosing the *neural space*. The neural canal, encloses the spinal cord, formed by the neural spaces of the serially arranged vertebrae. The neural arch bears a median *spinous process* and a pair of *transverse processes* and serve for the attachment of ligaments and muscles.

The neural arch of each vertebra has two pairs of *articulating facets*, one above and one below, at the base of the transverse processes where adjacent vertebra articulate. Between the centre of



Typical vertebra of man

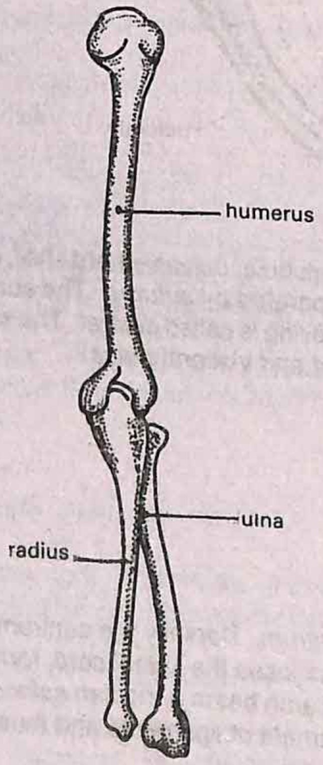
adjacent vertebrae, there are pads of cartilage called intervertebral discs serving as cushions for absorbing shocks.

The human skull

The skull is the skeleton of the head consisting of the *cranium* (brain box) and the face. The former has eight bones and the latter fourteen. Most of the bones of the skull are immovably joined.

The eight bones that make up the wall of the cranium are flat, slightly arched and immovably joined to provide maximum protection to the brain. The immovable joints on the cranium, marked by zig-zag lines, are called *sutures* . At the back of the base of the cranium is a large opening, the *foramen magnum,* through which the brain is joined to the spinal cord.

The face is the front part of the skull consisting of fourteen bones, most of which are irregular. A pair of orbits (sockets for the eyes), an upper and a lower jaw are distinct in this region of the skull. The only movable bone in the skull is the mandible that forms the lower jaws (refer page 70, Ch. 1 for figure).



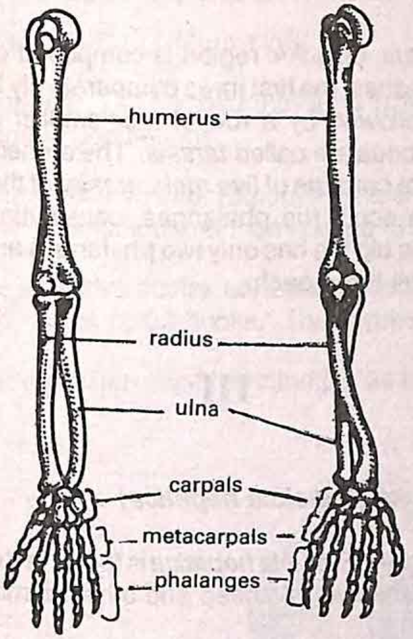
Humerus, radius and ulna

Bones of human forelimb

The humerus is the bone of the human upper arm or forelimb. It is elongated, cylindrical and stout. The proximal end bears a distinct head and greater and lesser tuberosities (a prominence on a bone). Proximally it articulates with the *glenoid cavity* of the pectoral girdle by the head and distally with the *radius* and *ulna*. The humerus has a depression on its lower back surface. Into this depression, a projection from the ulna, one of the two bones of the lower arm fits when the arm is straight.

The radius and ulna

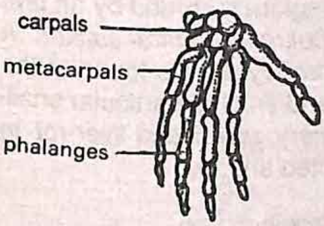
Radius and *ulna* are the bones of lower arm of human forelimb. Both bones articulate movably with each other instead of being fused. The radius (on the thumb side) can be rotated about the ulna, so that the hands can be placed palms upward (supine position) or downward (prone position). Proximally the radius and ulna articulate with the external surface of the humerus and distally with the carpals (wrist-bones).



The bones of the right arm A. in supination; B. in pronation

Carpals, metacarpals and phalanges

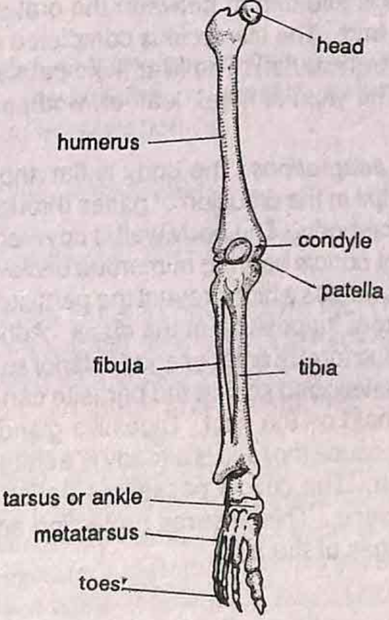
The human wrist consists of two rows, each of 4 bones, known as *carpals,* while the palm is composed of five bones known as *metacarpals.* The fingers are made up of separate *phalanges,* three in each *finger* and two in the *thumb.* The carpals articulate with the ulna and radius on one side and metacarpals on the other side.



Carpals, metacarpals and phalanges.

The bones of the leg

The femur is the bone of the thigh of the hind-limb. It is long and straight, expanded at both the ends. Its proximal end bears a rounded head and distally it bears two prominent rounded *condyles* for the articulation with the *tibia* and *fibula.* Proximally it articulates with the pelvic girdle by gliding its head into the acetabulum.

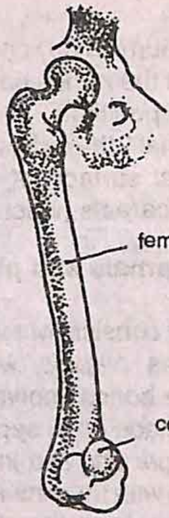


The bones of the right leg

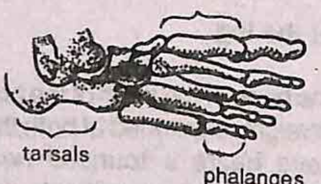
Tibia, fibula and patella

Tibia and fibula are the bones of the shank of the human hindlimbs. The tiba is quite a thick and straight bone expanded at both the ends. The fibula is a very slender bone, firmly fixed to the tibia at both ends, so that rotation as with the radius and ulna is possible.

The knee joint, between the lower end of the femur and the upper end of the fused tibia and fibula, is covered by a rounded bone the *patella* or *kneecap.*



Femur



Tarsals, metatarsals and phalanges

Tarsals, metatarsals and phalanges.

The *tarsus* or *ankle* region is composed of two rows of bones, the first three comparatively larger bones followed by a row of four smaller ones. These bones are called *tarsals.* The arched sole of the foot consists of five *metatarsals,* at the end of which occur the phalanges, constituting the toes. The big toe has only two phalanges and the other toes three each.

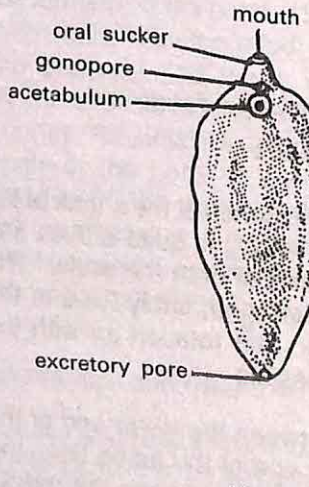
III

Liver fluke *(Fasciola hepatica)*

Occurence: Fasciola hepatica is found in the bile ducts of the liver of sheep and other animals.

Structure: It is commonly known as the *sheep liver fluke.* The body is leaf-like, dorso-ventrally flattened, measuring about 18-51mm in length and 4-15mm in breadth. The interior region is reduced into a conical projection called the *cephalic cone.* There is a small ventrally placed mouth at the anterior region, surround by an *oral sucker.* A little behind the mouth and oral sucker is an adhesive *acetabulum* or *ventral sucker.* A *gonopore* is situated in between the oral and ventral suckers. *The excretory pore* is found at the posterior end. The life cycle is completed in two hosts, namely, sheep and snail (a particular snail-Limneae truncatula.) The liver fluke causes *anaemia, diarrhoea, dysentery, ulcers* and *liver-rot* in sheep. The yield of meat, leather, wool, etc., is greatly reduced in infected sheep.

Parasitic adaptations: The body is flat and leaf-like. It helps in the diffusion of gases through the fluids of the body. The body wall is covered with a resistant *cuticle* bearing numerous backwardly directed *spinules* which prevent the parasite from slipping from its position in the ducts. Adhesive organs in the form of anterior and posterior suckers are well developed so that the parasite can get a firm foot-hold on the host. Digestive glands are absent because the food is already is a state fit for absorption. The cuticle possesses antienzyme on its surface. This ensures protection against the enzymes of the host.



Liver fluke

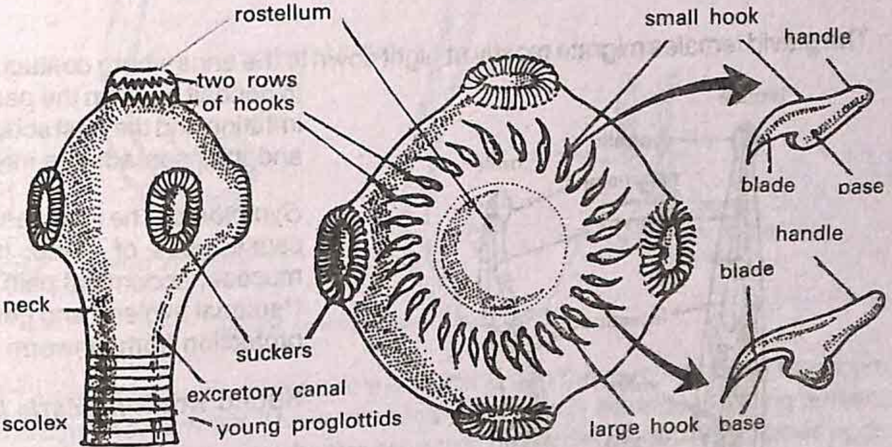
Pork tapeworm *(Taenia solium)*

Occurrence: Taenia solium is found in the intestine of man. This tapeworm is found endemic in pork-consuming populations.

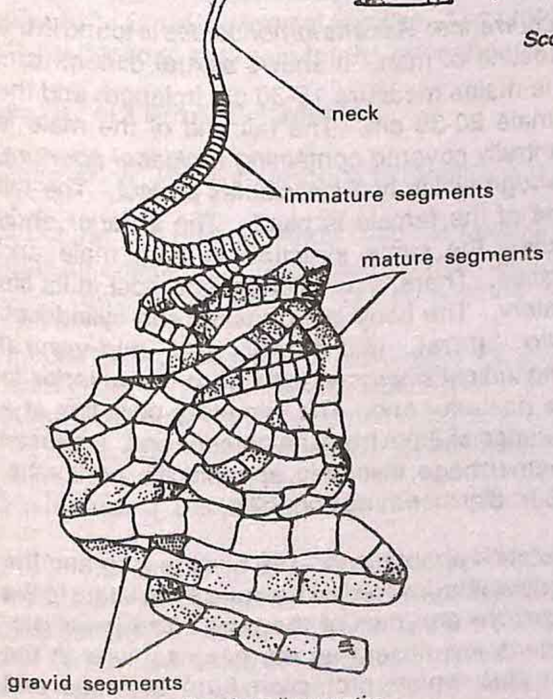
Structure: The anterior region is differentiated into a *scolex*, followed by a *neck* which is the area of mere segmentation and then a large number of *immature*, *mature* and *gravid* segments.

The adhesive scolex consists of four suckers and a rounded *rostellum*, crowned at its base by a double row of 28-32 hooks. The segments numbering 700-800, measure 4-5 metres in length.

Taenia solium must have the pig as an intermediate host to complete its life cycle . The pig gets infected by eating contaminated human faeces. Man gets infected by consuming inadequately cooked infected pork.



Scolex (enlarged)



Taenia solium, entire

Parasitic adaptation:

Morphological adaptations:

The body is flat to have a firm foot-hold on the host's intestinal wall. The animal's rostellum is provided with suckers and hooks. The body is ribbon shaped and comprises numerous proglottides. The parasite thrives on semi-digested and digested food which it absorbs through the general body surface and so there is no alimentary canal. Respiration is anaerobic. The excretory system is the flame-cell type and helps in osmo-regulation. *Taenia solium* has a tremendous rate of multiplication.

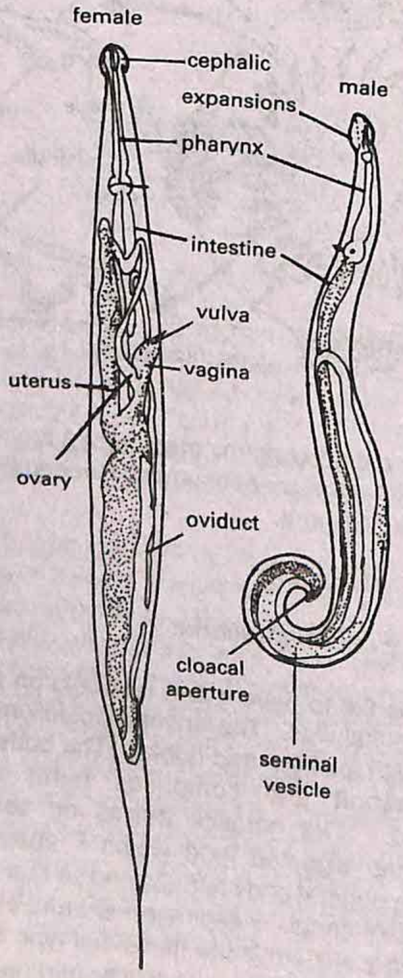
Physiological adaptations: The elastic protective *cuticle* protects the worm against digestion by the host's alkaline digestive enzymes. The pH tolerance is high, i.e., 4 to 11. The eggs are released only in the intestine of the host, in order to experience both acidic and alkaline mediums.

Pinworm *(Enterobius vermicularis)*

Occurrence: Enterobius vermicularis is commonly known as *pinworm* or *seatworm.* It is found all over the world and practically everyone suffers from its infection in infancy. The adult worms inhabit the caecum, appendix and neighbouring parts of the intestine.

Structure: The mouth is bordered by three lips. The anterior region has a pair of cuticular expansions, the *lateral alae.*

The gravid females migrate mostly at night down to the anus where contact with air stimulates them to deposit eggs on the perianal skin. This causes irritation and the host scratches the perianal area, and thus spreads the infection.



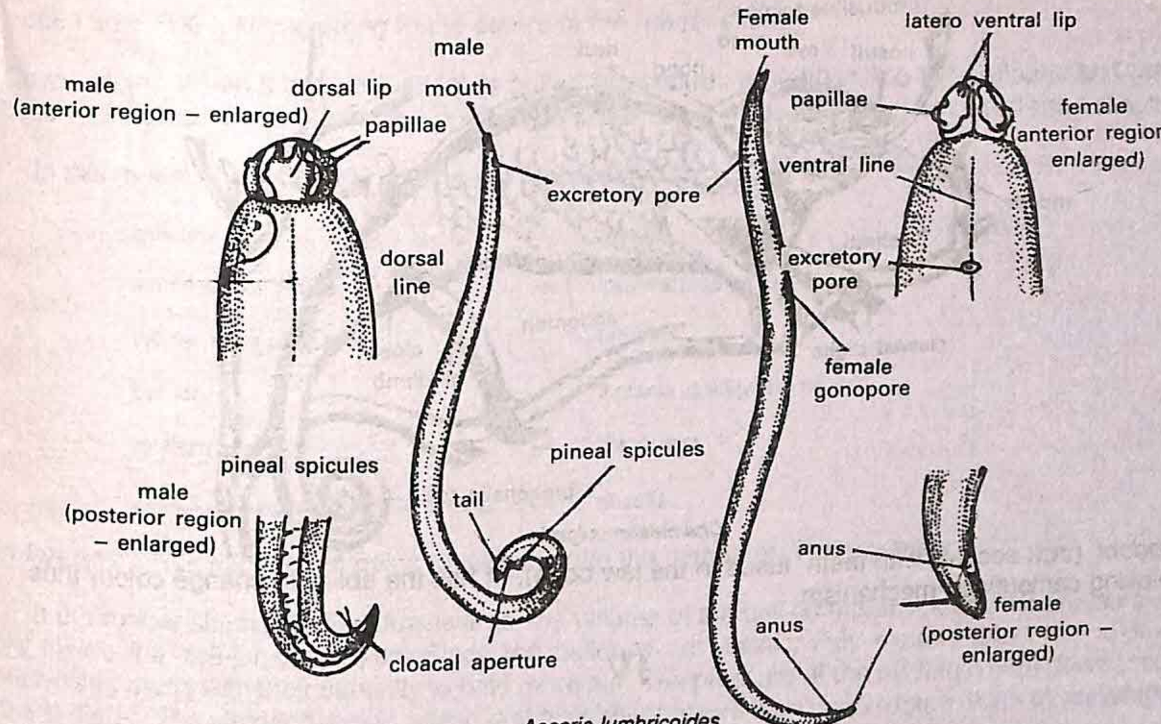
Pinworm (Enterobias vermicularis)

Symptoms: The infection known as *enterobiasis,* causes loss of sleep, inflammation of caecal mucosa, abdominal pain and even appendicitis. Personal hygiene and general sanitation provide protection from pinworm infection.

Round worm *(Ascaris lumbricoids)*

Occurrence: *Ascaris lumbricoides* is found in the intestine of man. It shows sexual dimorphism. The males measure 15-30 cm in length and the female 20-35 cm. The tail end of the male is ventrally covered containing a *cloacal aperture,* through which two *isospicules* project. The tail end of the female is blunt. The anterior ends exhibit the same structure in both male and female. There is no intermediate host in its life history. The body is elongated and cylindrical. Two lateral, mid-dorsal and mid-ventral longitudinal chords extend from the anterior to the posterior end. The excretory pore lies at a distance of 2mm from the anterior end. It causes haemorrhage, insomnia, appendicitis, peritonitis, ulcer, diarrhoea, eosinophilia, etc.

Parasitic adaptations: The body is long and the body wall is covered with a cuticle, resistant to the digestive enzymes of the host. The locomotor organs are absent as the parasite lives in the intestine where protection from enemies and



Ascaris lumbricoides

food supply is ensured. The pharynx is muscular and the worm sucks the semi-digested food from the host. The respiration is almost *anaerobic.* The sense organs are poorly developed, being present only on the lips in the form of *papillae*. The reproductive system is highly developed. Numerous eggs are produced to make up for the poor chance of the right host being reached.

Leaf Insect *(Phyllium seythe)*

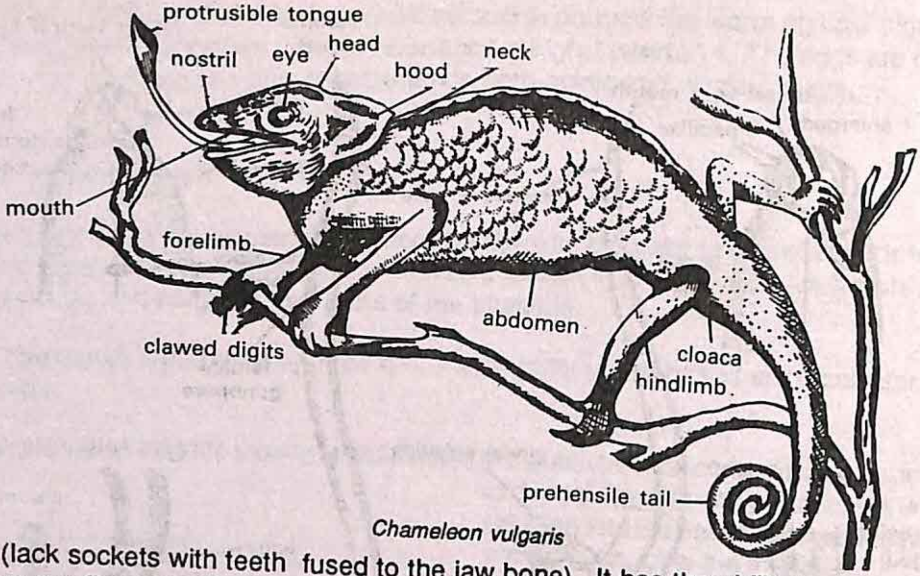
Occurrence: Phyllium is found in forests. It is commonly known as the leaf insect.

Structure: The body is divided into the *head, thorax* and *abdomen.* The head is small, containing small *antennae.* The thorax is also small, containing three pairs of flattened leaf-coloured legs. .The males have narrow bodies. The body of the female is very much expanded.

Adaptation: (camouflage or mimicry) It is a good example of *mimicry,* as the wings of the insect are flattened, green and thus resemble a leaf. The insect resembles and matches the foliage on which it feeds, so much that it becomes invisible. Even the wings are veined like leaf-veins. Here mimicry is a *protective device* to deceive its enemies. (See pg. 108 Ch.6 for illus.)

Chameleon *(Chameleon vulgaris)*

The chameleon is an arboreal lizard. Its skin is covered with minute *tubercles.* The body and head are laterally compressed. The head usually forms a casque with prominent crests and tubercles. The eyes can be moved separately from each other. The tongue is spoon–shaped, extremely protrusible and sticky. The limbs are large and slender. Each limb forms groups of three and two digits, which are used in grasping twigs. The tail is long and *prehensile*(capable of grasping). The teeth are



Chameleon vulgaris

acrodont (lack sockets with teeth fused to the jaw bone). It has the ability to change colour thus exhibiting camouflage mechanism.

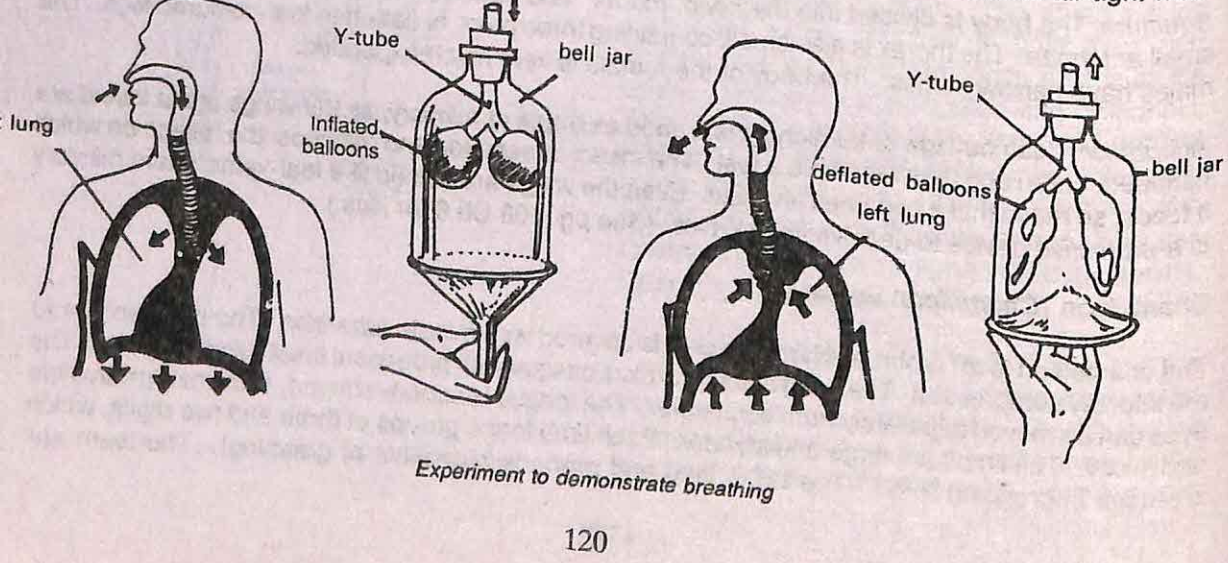
IV

To demonstrate the mechanism of breathing (Bell jar experiment)

Aim: To demonstrate the breathing mechanism in human beings.

Apparatus: Bell jar, one-holed rubber stopper, glass 'Y'-tube, a rubber sheet, string and thread.

Procedure: At the two ends of 'Y'-tube tie two balloons with thread. Now pass the third arm of the Y-tube through a hole in a cork fitted into the mouth of a bell jar. Make the connections air-tight with



Experiment to demonstrate breathing

molten wax. Tie a strong string to the centre of the rubber sheet.

Observation: When the rubber sheet is pulled downwards air rushes into the balloons and they become inflated. On releasing the pull of the rubber sheet, it takes up its normal flattened shape.

In this model, the breathing organs are represented by:

balloons	—	Lungs
single arm of Y-tube	—	trachea(wind pipe)
the two arms of 'Y' tube	—	bronchi
bell jar	—	thoracic cavity(chest cavity)
rubber sheet	—	diaphragm
opening of single arm of the 'Y'-tube.	—	nostrils

Inference: This experiment helps to demonstrate the mechanism of breathing.

If the rubber sheet is pulled downwards, the volume of the bell-jar increases and the pressure of air inside the bell-jar decreases. Since the balloons are elastic, they expand and their volume increases along with their capacity to hold more air. The pressure of the air within then decreases. Immediately, the atmospheric air, which is at a higher pressure than the pressure of the air inside the balloons, rushes into the balloons through the 'Y' tube to inflate them.

On releasing the rubber sheet, it takes up its normal flat shape. The volume of the bell-jar decreases, the balloons get compressed, the pressure of the air inside them increases, and so the air rushes out of the balloons and they become deflated once again.

TEST PAPER I

Time: 2½ hrs.

I *Choose the correct answer.*

1. The barrier between the protoplasm and the outer environment in an animal cell is

   a) plasma membrane. b) cell wall. c) tonoplast. d) nuclear membrane.

2. Ribosomes play a significant role in

   a) lipid synthesis. b) photosynthesis. c) protein synthesis. d) secretion.

3. The nuclear membrane and the nucleoli become indistinguistable during

   a) prophase. b) interphase. c) metaphase. d) telophase.

4. The cell secretion is asssociated with

   a) mitochondia. b) Golgi bodies. c) lysosomes. d) ribosomes.

5. The number of chromosomes in the somatic cell of man is

   a) 46. B) 44. C) 48. d) 50.

6. The number of chromosomes in each species is maintained by

   a) amitosis. b) mitosis. C) meiosis. d) none of the above.

7) The longitudinal splitting of chromosome takes place in

   a) prophase. B) anaphase. c) metaphase. d) telophase.

8) Karyokinesis is the division of

   a) centromere. b) nucleus. c) chromosomes. d) cytoplasm.

II *Fill in the blanks:*

1. The food is passed along the oesophagus by the muscle action called ______.
2. ______________ helps in converting milk to ____________.
3. Lack of water in the cells of an organism causes ____________.

4. In aquatic lower organisms, exchange of gases takes place by the process of __________ .
5. __________ discovered the cell.
6. __________ and __________ formulated the cell theory.
7. __________ is the powerhouse of the cell.
8. The non-living substances of the cytoplasm are called __________ .
9. __________ are called suicidal bags of the cell.
10. The chromosomes are classified into __________ and __________ .
11 Mitosis is also known as __________ division.
12. The duplication of chromosome takes place in __________ .

III *Mark the following statements true (T) (or) false (F)*

1. Plasma membrane is present is all cells. ☐
2. Nucleus contains deoxy ribonecleic acid and proteins. ☐
3. Plastids always contain coloured pigments. ☐
4. Vacuoles are surrounded by a membrane known as tonoplast. ☐
5. Ribosomes are made up of deoxy ribonucleic acid and proteins. ☐
6. Plant cells are bounded by a wall made up of cellulose. ☐
7. Meiosis occurs in gametes. ☐
8. Mitosis leads to an increase in the number of cells. ☐

IV *In which stage of cell division do the following occur?*

a) Disappearance of nuclear membrane. b) Development of spindle.
c) Migration of chromosomes. d) Reappearance of nuclear membrane.
e) Condensation of chromatin into chromosomes.

V *Distinguish between:*

1. ribosome and centrosome. 2. endoplasmic reticulum and chromatin
reticulum. 3. cell wall and cell membrane. 4. nucleolus and nucleus.
5. chromatin and chromatid. 6. centromere and centriole. 7. karyokinesis
and cytokinesis. 9. ingestion and egestion. 10. absorption and assimilation.

VI *Answer the following questions briefly:*

1. What is the significance of cell wall in plant cells?
2. What is the structure of Golgi body? Mention its functions.
3. Compare the structure and functions of mitochondria and lysosomes.
4. Name the organelles which are bounded by membranes and indicate whether the membranes are single or double.
5. Name some organelles which are present only in plant cells and those which occur only in animal cells.
6. In what ways is our knowledge of cell division useful in the control of cancer?
7. Name the digestive organs in man.
8. Name the functions of saliva, bile, pepsin, amylase and lipase.
9. Enumerate the respiratory organs in man.
10. What do you mean by aerobic and aneaerobic respiration? Give examples.

VII *Answer the following in detail:*

1. Give an account of the cytoplasmic organelles is an animal cell as seen under an electron microscope.
2. Draw labelled sketches to show the different phases of mitosis. Enumerate the salient features.
3. Differentiate between plant and animal cells.
4. Draw a labelled diagram of the alimentary canal in man.
5. How is digested food absorbed in the body?

IX *Write short notes on:*

1. axial skeleton. 2. pectoral girdles. 3. bones of the lower limb. 4. nucleus.
5. properties of enzymes. 6. contamination of food.

TEST PAPER II

I *Choose the correct answer.*

1. Darwin's concepts of evolution

   a) have been completely refuted. b) are accepted today in toto. c) rejected the inheritance of acquired characteristics. d) are the basis of modern theory of evolution.

2. The Biogenetic law is propounded by

   a) Harvey. b) Earnest Haeckel. c) Lamarck. d) Aristotle.

3. To be evolutionary successful, a mutation must occur in

   a) germplasm DNA. b) plasma protein. c) somatoplasm DNA. d) RNA.

4. Genetics is the study of

   a) reproduction. b) cell division. c) growth and diffrentiation in living organisms. d) the mechanism of inheritance.

5. An insect commonly used in the study of genetics

   a) housefly. b) mosquito. c) Drosophila. d) butterfly.

6. Mutations are

   a) always useful. b) mostly useful. c) always harmful. d) rarely useful.

7. The genetic material of a virus is

   a) RNA only. b) DNA only. c) RNA or DNA. d) none of the above.

8. The basic mechanism of heredity transmission is

   a) mutation. b) polyploidy. c) sexual reproduction. d) vegetative reproduction.

9. Homologous organs are

   a) similar in function. b) similar in origin. c) similar behaviour. d) similar in origin and function.

10. Analogous means

a) similar in origin. b) similar in behaviour. c) similar in function. d) none of the above.

11. Parasites are those which are

a) found on the decaying organisms. b) found on other organisms and cause no harm. c) provide shelter to other organisms. d) found on the living organism and deprive it of its nutrients.

12. The reproductive system of a parasite is

a) disintegrated. b) less complex than that of free living animal. b) very similar to that of other animals. d) very complex.

II Answer the following questions:

1. What is food contamination? Name the sources of food contamination.
2. What is food poisoning and how is it caused?
3. Name the steps that can be taken to keep hygienic conditions in the kitchen.
4. Describe the fossil history of horse.
5. What are vestigeal organs?
6. Discuss Darwin's theory of natural selection.
7. Describe the theory of racapitulation.
8. Differentiate between variations and mutations.
9. Give an account of any three evidences of evolutions.
10. Give the various types of variations.
11. Give an account of the marine habitat.
12. Describe the freshwater habitat.

III Write short notes on:

1. Abiogenesis.
2. Biogenesis.

3. Haeckel's theory.
4. Von Baer's concept.
5. Stanley Miller's experiment.
6. Louis Pasteur's contribution towards evolutions.
7. Darwin's theory of evolution.
8. DNA and RNA.
9. Fossorial adaptation.
10. Epiphytes.
11. Aquatic adaptation.
12 Terrestrial habitat .

IV Differentiate between the following pairs:

1. Interspecific and intraspecific struggle (struggle for existence).
2. Struggle for existence and survival of the fittest.
3. Theory of special creation and catastrophism.
4. Theory of abiogenesis and biogenesis.
5. Concepts of Stanley Miller and Louis Pasteur regarding organic evolution.
6. Cosmozoic theory and theory of spontaneous creation.
7. Homologous and analogous organs.
8. Palaeontology and embryology.

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